THE ELECTRICAL AGE

VOLUME XXXIII

July—December, 1904

NEW YORK AND LONDON

INDEX TO VOLUME XXXIII

PAGE.

Abyssinia, Difficulties of Telephone Line Construction in.. 185
Adams, Alton D.:
  Prices of Electrical Energy in Bulk 16
  Electric Transmission Lines 145
  Entries for Electric Transmission Lines 174
  The Value of Water Power 277
  The Commercial Development of Water Power 361
  Electric Omnibuses vs. Street Cars 373
  Electric Traction on Steam Railways 417
Advances in the Use of Electricity, Prospective 80
Advantages of Electric Motors Over the Steam Engine, The. 380
Alternating-Current Railway in America, The First Commercial 186
Aluminium:
  Electrical Conductors, Roderick J. Parke 223
  The Production of, in the United States 416
Anthracite Coal Field, Electric Power in the 369
Australia, Street Car Fares in 176
Auto-Cars, Railway 79
Automobile:
  The Electric, as a Public Conveyance in Great Britain.. 376
  An, School 416
Automobiles:
  Electric, in British Post Office Service 324
  Versus Horses for Police Work 116
Auxiliaries, Electric Power Plant 77
Barrus, George H.:
  The Choice of a Steam Plant 7
Baths, Electric Light 208
Behrend, B. A.:
  Testing Alternating-Current Generators 199
Berlin Rapid Transit System, Safety Device for the 168
Blanck, W. A.:
  Single-Phase, Electric Railroads 262
Boiler:
  Power in Electric Light and Power Stations 100
  The Rust Water Tube 311
Book Reviews:
  Anthracite Coal Communities, The. Peter Roberts 207
  Art of Wise Investing. The Moody Publishing Co 449
  Condensation of Steam in Covered and Bare Pipes. Charles P. Paulding 43
  Discount Book, The Thomas. Millward T. Thomas... 157
  Electro-Magnetic Machinery and Other Apparatus, Testing of. B. V. Swenson and B. Frankenfield 45
  Electrical Engineering Experiments and Tests on Direct-Current Machinery. George F. Sever 45
  Engineering Student's Notes, An. J. Richards 449
  Friction and Lubrication. William M. Davis 44
  International Fire Prevention Congress at London. Ira H. Woolson 207
  Machine Design, Part I.: Fastenings. William Ledyard Cathcart 156
  Manual for Engineers. Charles E. Ferris 157
  Motors, Electric. Henry M. Hobart 207
  Polytechnic Engineer, The 157
  Radio-Activity. E. Rutherford 44
  Static Electricity. Hobart Mason 156
  Wireless Telegraphy, Maver's. Wm. Maver, Jr 44
  Wiring Diagrams and Descriptions, Modern. H. C. Horstman and V. H. Tousley 45
Boston, Electrolysis of Water Mains in 240
British:
  Precautions Against Subway Disasters 167
  Electric Automobiles in, Post Office Service 324
  Zone Fares on, Electric Railways 363
  Fire Rules for Electric Motors in, Textile and Corn Mills. 379
  Naval Use of the Wireless Telegraph 433
Brown, C. S. Vesey:
  Electric Power in British Shipyards 209
Cables in Manholes, Protecting Electric 46
Cable:
  High-Tension, Crossings 47
  Laying and Telegraph Line Construction in Alaska. George E. Walsh 333
  Using Roentgen Rays in, Factories 475

PAGE.

California, Recent Electrical Mining Developments in 289
Canada:
  Electric Railways in, Acquired by Steam Roads 48
  Electrical Progress in 65
  Electrical Progress in. George Johnson 169
  Electrical Smelting of Iron and Steel in 379
Capacities of New York Street Railways, Passenger-Carrying 105
Cartridge for Coal Mining, An Electric Water 149
Central Station vs. Isolated Plant, Electric 371
Charging Stations, Experiences with Electric Automobile. J. W. Cowles 367
Chemical Industry, The Society of 28
Chimney, A Big Boiler 462
China, Doing Business with 79
Clark, George L.:
  Electric Safeguards for Ocean Travel 398
Cockerill Gas Engine in America, The 466
Commercial Supremacy in South Africa, American 207
Commutator-Truing Devices 461
Competition, Wireless and Submarine Telegraph 131
Conductors, Aluminium Electrical. Roderick J. Parke 223
Construction:
  And Insulation of High-Tension Transmission Lines. M. H. Gerry, Jr 177
  Electric High-Tension Line, and Operation. F. A. C. Perrine 342
Converse, V. G.:
  High-Tension Insulators 434
Cooking with Electricity. D. A. Willey 392
Cooper Hewitt Lamp in Electrotherapeutics, The 306
Copper:
  Production of the World 41
  Production in the United States 306, 410
  Exports and Imports of 460
Cost of Municipal Electric Lighting, The 75
Cowles, J. W.:
  Experiences with Electric Automobile Charging Stations 367
Criminality, Electric Lighting and 110
Current-Collecting Devices in Third-Rail Practice. J. Eugene Wallace 34
Current-Collectors for Trolley Cars, Foreign Overhead 38
Cutting-Off Machine, A Motor-Driven 152
Depreciation on Electric Railways. W. E. Harrington 319
Derrick, A 150-Ton Electrically Operated 63
Design and Operation, Some Points in Electric Station. Howard S. Knowlton 124
Disruptive Effects of Direct and Alternating Currents, The Relative 376
Destruction of Harmful Insects by Electricity, The 352
Drafting-Room Apprenticeship Course of the General Electric Co., The. John W. Upp 157
Drilling Machine, A German Electric 380
Edison Company Banquet, An 470
Egyptian Markets for American Electrical Machinery 15
Electric Light and Power Enterprise in Great Britain 46
Electric Power from Shawinigan Falls in Canada 6
Electric Roads vs. Steam Roads in Great Britain 433
Electrical Development, Eras in. Charles F. Scott 407
Electricity:
  In Farming. Hanford C. Judson 1
  Prospective Advances in the Use of 80
  In the Jewelry Trade 205
  In Swedish Iron Mines 306
  In Sea Coast Defense. M. C. Sullivan 401
  In Fire Fighting 416
  In Textile Mills. Charles Robbins 428
  And Physics 449
  In the Twentieth Century. Howard S. Knowlton 454
  On the U. S. Battleship "New Jersey" 461
Electrolysis:
  Of Underground Water Mains. A. A. Knudson 172
  Of Water Mains in Boston 240
Electrolyte, Storage Battery 203
Electromagnet for Surgical Purposes, A Large 90

PAGE.
Electrotherapeutics, The Cooper Hewitt Lamp in 306
Emmet, W. L. R.:
The Steam Turbine in Central-Station Practice 336
Energy, Electrical, Direct from Coal. J. Wright 476
Engines:
For the New York Subway 14
Electric Winding 78
Engine, The Mietz & Weiss Kerosene Oil 149
Engineering:
Costly Amateur Electric. Egbert P. Watson 5
The Outlook for Electrical, in Germany 45
Entries for Electric Transmission Lines. Alton D. Adams .. 174
Eras in Electrical Development. Charles F. Scott 407
Europe:
The First 40,000-Volt Power Transmission in 301
Electric Railways in 341
European Electrical Practice, Notes on. Clayton H. Sharp. 25
European Telephone Development 77
Execution by Electricity 237, 256
Exhaust Steam, Steam Turbines Using 76
Exhibition, An International, at Liege, Belgium 480
Exhibits at the St. Louis Exposition, Notable Electrical. Cloyd Marshall 18
Exhibitors at the St. Louis Exposition, Electrical 70
Fassett, F. G.:
The Latest Form of Radiophone 23
Finances of Electric Railways. Wm. D. Marks 117
Fires Caused by Electricity 206
Fire:
Electric, Risks. Hubert S. Wynkoop 59
The Electrical, Hazard. J. C. Forsyth 104
Streams as Electric Conductors 370
Electric Lamp, Dangers 376
Electricity in, Fighting 416
Ford, Alexander Hume:
Trolley Cars in Other Climes 81
Forsyth, J. C.:
Electrical Fire Hazard 104
Freight:
The Handling of, by Electric Roads. Lemuel W. Serrell. 357
Carriage by Trolley Lines 451
Fuel Economy in Electric Station Steam Plants. John B. C. Kershaw 269
Furnace, Popular Interest in the Electric 410
Future of the Rotary Converter, The 130
Gairns, J. F.:
Electric Locomotives 91
Galvanometer, The Development of the. J. Wright 30
Gambling Device, A Fraudulent Electric 58
Gas Engines:
Vs. Electric Motors. Fred. M. Kimball 274
Water Required for 480
Gas-Engine Dynamo, A 311
Gas Power, Electric Traction from 466
Generators:
The Increasing Size of Electric 153
Testing Alternating-Current. B. A. Behrend 199
General Electric Company, The Drafting-Room Apprenticeship Course of the. John W. Upp 157
Germany:
Exploiting of Water Power in 17
The Outlook for Electrical Engineering in 45
German:
Electrical Industries 29
Some, Electric Tramway Data 256
School for Employees of Electric Plants 332
A, Electric Drilling Machine 380
Gerry, Jr., M. H.:
Construction and Insulation of High-Tension Transmission Lines 177
Glower Earths in the United States, The Production of 289
Gradenwitz, Alfred:
Portable Wireless Telegraph Apparatus for War Service. 282
Graduates, Incomes of Technical 165
Great Britain:
Electric Light and Power Enterprise in 46
The Electric Automobile as a Public Conveyance in 376
Electric Roads vs. Steam Roads in 433
Gutta Percha Insulation, Artificial 185
Hamilton-Holzwarth Steam Turbines, The 308
Hale, R. S.:
Smoke Prevention 411
Hamilton, James:
The New Australian Patent Law 282
Hancock, L. M.:
Electric Power Transmission on the Pacific Coast 241
Harrington, W. E.:
Depreciation on Electric Railways 319

PAGE.
Headlights on Indian Trains, Electric 400
Heating:
Electric, Apparatus at the St. Louis Exposition 453
Kryptol, A New Substance for Electric 409
High-Tension:
Cable Crossings 47
Electric, Line Construction and Operation. F. A. C. Perrine 342
Hoists, Electric Traveling 377
Hoist, A Portable Electric 61
Hong Kong, Electric Traction at 208
Howell, Wilson S.:
The Importance of Testing 27
Howes, Robert:
A 100-Mile Electric Transmission Line 135
Hull Tramways, The 208
Hydro-Electric Power in Mexico 99
Incomes of Technical Graduates 165
Indicating a Steam Turbine 75
Induction Motor in the Carpet Mill, The 450
Insects by Electricity, The Destruction of Harmful 352
Instruction for Railway Telegraph Operators, Technical 134
Insulating Materials, Desirable Features in 368
Insulation:
Artificial Gutta Percha 185
Varnished Cambric, for High-Tension Circuits 465
Insulators, High-Tension. V. G. Converse 434
International Electrical Congress, The 71
International Electrical Congress, Nuggets from the 273
Interurban Traffic, The Control of 80
Iron, Electrolytic 76
Jewelry Trade, Electricity in the 205
Johnson, George:
Electrical Progress in Canada 169
Judson, Hanford C.:
Electricity in Farming 1
Wind-Mill Electric Plants 257
Jumper, H. W.:
Electrical Display at the Knights Templar Conclave 321
Kershaw, John B. C.:
Fuel Economy in Electric Station Steam Plants 269
Kimball, Fred. M.:
Gas Engines vs. Electric Motors 274
Knights Templar Conclave, Electrical Display at the. H. W. Jumper 321
Knowlton, Howard S.:
Some Points in Electric-Station Design and Operation. 124
Electricity in the Twentieth Century 454
Knudson, A. A.:
Electrolysis of Underground Water Mains 172
Kryptol, A New Substance for Electric Heating 469
Laboratories, Notes on European Testing. Clayton H. Sharp 231
Langer, Joseph J.:
Trackless Trolley Lines in Germany 390
Lathes, Electric Motor-Driven 152
Life-Saving Service, Electric Railway in 90
Lights, Vacuum-Tube and Other Electric 190
Lighting:
The Cost of Municipal Electric 75
Electric, and Criminality 110
Lightning:
Sir Oliver Lodge on 110
Its Causes and Effects. H. W. Spang 121
Statistics 148
Research 203
Protection Against 239
Locomotives:
Electric and Compressed Air, for Mines 78
Electric. J. F. Gairns 91
Testing Electric 110
Electric Gathering 149
Electric Mine 312
Electric, for Steam Railroad Service. By a Staff Correspondent 440
Electric Freight, on the North-Eastern Railway of Great Britain 466
Locomotive:
A Storage-Battery Factory 151
Electric, Repairs 204
An Electric, for the Philadelphia & Reading Railroad .. 430
Lodge on Lightning, Sir Oliver 110
Magnets for Eye Surgery 168
Magnetic Separation. F. T. Snyder 219
Manganese, Magnetic Alloys of 78
Manila Electric Street Railway, The 48
Marks, Wm. D.:
Finances of Electric Railways 117

Page.

Marshall, Cloyd:
Notable Electrical Exhibits at the St. Louis Exposition. 18
New Applications of Electric Motors at the St. Louis Exposition 111
Electricity Day at the St. Louis Exposition 359
Mason, Frank H.:
Electric Railways in Germany 42
Mathematics in Engineering. Thorburn Reid 302
Maver, Wm., Jr.:
Notes from the Tour of the Visiting Foreign Electrical Engineers 299
Thawing Out Frozen Water Pipes Electrically 353
McKillop, Dugald M.:
A Thomson-Houston Coterie of 1893 409
Meters, Electrolytic. H. W. Young 106
Mexico, Hydro-Electric Power in 99
Mietz & Weiss Kerosene Oil Engine, The 149
Mines, British Rules for the Use of Electricity in 228
Mining Developments in California, Recent Electrical 289
Moody, Walter S.:
Terminals and Bushings for High-Pressure Transformers 128
Motor:
A, for Driving Machine Tools 62
The Induction, in the Carpet Mill 450
The Electric, for Speed Regulation. Dr. Schuyler S. Wheeler 459
Motors:
New Applications of, at the St. Louis Exposition. Cloyd Marshall 111
The Advantages of Electric, Over the Steam Engine 380
National Electric Light Association, Twenty-eighth Convention of the 471
Nernst Lamp, The. E. R. Roberts 395
"New Jersey," Electricity on the U. S. Battleship 461
New York:
Passenger-Carrying Capacities of, Street Railways 105
Fast Time in the, Subway 278
Niagara Power for Toronto, Canada 208
Oi, Saitaro:
Telegraphy and Telephony in Japan 293
Oil Engines vs. Steam Engines for Driving Electric Generators 427
Omnibuses vs. Street Cars, Electric 370
Omnibuses vs. Street Cars, Electric. Alton D. Adams 373
Ore Finding, Electrical 102
Oven for Chemists, An Electric 153
Parke, Roderick J.:
Aluminium Electrical Conductors 223
Patent Law, The New Australian. James Hamilton 286
Perrine, F. A. C.:
Electric High-Tension Line Construction and Operation 342
Persia, The Telegraph in 168
Philippines, Electrical Enterprise in the 289
Pipe-Threading and Cutting-Off Machine, A Motor-Driven. 379
Piping, Power Station 291
Plant in British Central Africa, An Electric Lighting 153
Plants in Foreign Countries, Electric 129
Portraits:
Ayrton, W. E 387
Bell, Louis 472
Brainerd, L. B 66
Carnegie, Andrew 387
Chesney, C. C. 66
Crompton, R. E 234
Davis, E. H 471
Day, Charles 67
Dodge, Kern 67
Duncan, Louis 387
Dunwoody, H. H. C 234
Edgar, Chas. L 236
Freeman, John R 387
Hewitt, Peter Cooper 472
Lieb, Jr., J. W 470
Maver, Jr., William 471
McCall, Joseph B 235
Peck, J. S 386
Perkins, J. H 472
Perry, John 234
Serrell, L. W 387
Smith, A. W 67
Unwin, W. C 65
Williams, Arthur 470
Post Office, A Motor-Drawn Itinerant 393
Power:
Why Electric, Distribution Sometimes Fails .90
Electric, in Marble Quarries 158

Page.

Power:
Electric, in British Shipyards. C. S. Vesey Brown 209
Electric, in the Anthracite Coal Field 369
Consumption on Electric Railways 389
Power-Plant Equipment Notes from the St. Louis Exposition. D. T. Randall 192
Prices of Electrical Energy in Bulk. Alton D. Adams 16
Prize for High-Tension Safety Apparatus, A 208
Problems of Heavy Traction 458
Progress in Canada, Electrical. George Johnson 169
Protecting Electric Cables in Manholes 46
Protection Against Lightning 239
Pump:
The Widening Use of the Electric 292
A Motor-Driven Fire 314
An Automatic Electric, and Receiver 383
Push-Button Pendant and Switch, A New 383
Quarries, Electric Power in Marble 158
Radiophone, The Latest Form of. F. G. Fassett 23
Railroad:
An Electric, Up Mount Blanc 61
A New, Telephone Line 191
A New Electric, in Peru 363
Electric Locomotive for Steam Service. By a Staff Correspondent 440
Railway:
The Manila Electric Street 48
Auto-Cars 79
The First Commercial Alternating-Current, in America. 186
Railways:
Electric, in Germany. Frank H. Mason 42
Electric, in Canada Acquired by Steam Roads 48
Electric and Other Street, in the United States and Canada 268
Electric Traction on Steam. Alton D. Adams 417
Electric, in Europe 341
Single-Phase, Alternating-Current 347
Power Consumption on Electric 389
Randall, D. T.:
Power-Plant Equipment Notes from the St. Louis Exposition 192
Reid, Thorburn:
Mathematics in Engineering 302
Repairs, Electric Locomotive 204
Reversing Nature's Processes 48
Robbins, Charles:
Electricity in Textile Mills 428
Roberts, E. R.:
The Nernst Lamp 395
Rock Drill, The Box Electric 307
Roentgen Rays, Using, in Cable Factories 475
Rotary Converters, Large 378
Rotary Converter, The Future of the 130
Rowe, Bertrand P.:
Direct-Current Switchboards 325
Rubber Growing, New Fields for 320
Rules:
British, for the Use of Electricity in Mines 229
Underwriters, for Car Wiring and Equipment 239
Fire, for Electric Motors in British Textile and Corn Mills 379
Rust Water-Tube Boiler, The 311
Safeguards for Ocean Travel, Electric. George L. Clark 398
Safety Apparatus, A Prize for High-Tension 208
Safety Device for the Berlin Rapid Transit System 168
Sales, Developing Electric Current 204
School for Employees of Electric Plants, A German 332
Scott, Charles F.:
Long-Distance Power Transmission 364
Eras in Electrical Development 407
Selenium in Electrical Industry, The Importance of 75
Separation, Magnetic. F. T. Snyder 219
Serrell, Lemuel Wm.:
The Handling of Freight by Electric Roads 357
Shaper, A Variable-Speed, Motor-Driven 465
Shaping Machine, A Motor-Driven Double 65
Sharp, Clayton H.:
Notes on European Electrical Practice 25
Notes on European Testing Laboratories 231
Shawinigan Falls in Canada, Electric Power from 6
Shipyards, Electric Power in British. C. S. Vesey Brown 209
Single-Phase:
Electric Railroads. W. A. Blanck 262
Alternating-Current Railways 347
Size of Electric Generators, The Increasing 153
Sleeping Car on an Electric Railway, A 356
Smelting of Iron and Steel in Canada, Electric 379
Smoke Prevention. R. S. Hale 411

PAGE.
Snyder, F. T.:
Magnetic Separation ... 219
Society of Chemical Industry, The ... 28
South Africa, American Commercial Supremacy in ... 207
Spang, H. W.:
Lightning, Its Causes and Effects ... 121
Speed Regulation, The Electric Motor for. Dr. Schuyler S. Wheeler ... 459
Standardizing Electric Motors for Machine Tools ... 480
Stations, Boiler Power in Electric Light and Power ... 100
Stealing Copper Wire from Electric Circuits ... 371
Steam Plant, The Choice of a. George H. Barrus ... 7
Steel Making at Niagara Falls, Electric ... 148
St. Louis Exposition:
New Applications of Electric Motors at the. Cloyd Marshall ... 111
Wireless Telegraphy at the ... 161
Power-Plant Equipment Notes from the. D. T. Randall ... 192
Electricity Day at the. Cloyd Marshall ... 359
Electric-Heating Apparatus at the ... 453
Storage-Battery Electrolyte ... 203
Storms on Wireless Telegraphy, The Effect of Electrical ... 191
Stroboscope, Use of the ... 151
Subway:
Engines for the New York ... 14
British Precautions Against, Disasters ... 167
Sullivan, M. C.:
Electricity in Sea Coast Defense ... 401
Surgery, Magnets for Eye ... 168
Switchboards, Direct-Current. Bertrand P. Rowe ... 325
Switch, A New Push-Button Pendant ... 383
Technical Instruction for Railway Telegraph Operators ... 134
Telautograph in Railroad Service, The ... 314
Telegraphy:
And Telephony in Japan. Saitaro Oi ... 293
In the Congo States ... 306
Telegraphing in Japanese and Chinese ... 105
Telephone:
A New Use for the ... 41
The, in the United States. Herbert Laws Webb ... 49
European, Development ... 77
The, and Telegraph in Warfare ... 131
Difficulties of, Line Construction in Abyssinia ... 185
A New Railroad, Line ... 191
A Novel Method of Operating ... 198
A Novel Use for the ... 240
A Government, Plant ... 240
The Effect of the, on Railroad Passenger Receipts ... 410
The, in a Lumber Region ... 427
The Increasing Use of the. H. S. Webb ... 431
The, in the Recent Election ... 452
Telephones for Panama ... 475
Terminals and Bushings for High-Pressure Transformers. Walter S. Moody ... 128
Testing:
Electric Locomotives ... 110
The Importance of. Wilson S. Howell ... 27
Alternating-Current Generators. B. A. Behrend ... 199
Tests of Electric Motors and Other Figures, Some. Arthur Williams ... 279
Textile Mills, Electricity in. Charles Robbins ... 428
Thawing Out Frozen Water Pipes:
Electrically. William Maver, Jr. ... 353
A Transformer for ... 381
Practical Experience with Electrically ... 382
A Transformer for Electrically ... 464
Thermit, The Duty on ... 378
Third-Rail Practice, Current-Collecting Devices in. J. Eugene Wallace ... 34
Thomson-Houston Coterie of 1893, A. Dugald M. McKillop. 409
Tool-Lifting Attachment, A Magnetic, for Planers ... 464
Toronto, Canada, Niagara Power for ... 208
Tour of the Visiting Foreign Electrical Engineers, Notes from the. Wm. Maver, Jr. ... 299
Track-Tamping Machine, An Electric Railway ... 378
Trackless Trolley Lines in Germany. Joseph J. Langer ... 390
Traction:
Electric, at Hong Kong ... 208
Problems of Heavy ... 458
Electric, from Gas Power ... 466
Tramways, The Hull ... 208
Tramway Data, Some German Electric ... 256

PAGE.
Transformer:
The Testing of, Oil ... 268
A, for Thawing Out Frozen Water Pipes ... 381
A, for Electrically Thawing Out Frozen Water Pipes ... 464
Transmission:
A 100-Mile Electric, Line. Robert Howes ... 135
Electric, Lines. Alton D. Adams ... 145
Entries for Electric, Lines. Alton D. Adams ... 174
Construction and Insulation of High-Tension Lines. M. H. Gerry, Jr. ... 177
Electric Power, on the Pacific Coast. L. M. Hancock. 241
The First 40,000-Volt Power, in Europe ... 301
Long-Distance Power. Charles F. Scott ... 364
Trolley Cars in Other Climes. Alexander Hume Ford ... 260
Truck for Drawing in Subway Cables, An Electric ... 260
Turbine:
Steam, Progress ... 33
Indicating a Steam ... 75
Steam, Using Exhaust Steam ... 76
The Hamilton-Holzwarth, Steam ... 308
The Steam, in Central-Station Practice. W. L. R. Emmet ... 336
Typewriter, A Wireless Electric ... 33
Two-Wire System for Operating Trains of Cars, A ... 462
Upp, John W.:
The Drafting-Room Apprenticeship Course of the General Electric Company ... 157
Vacuum-Tube and Other Electric Lights ... 190
Wallace, J. Eugene:
Current-Collecting Devices in Third-Rail Practice ... 34
Walsh, George E.:
Cable Laying and Telegraph Line Construction in Alaska ... 333
War News by Wireless Telegraphy ... 130
Water Power:
Exploiting of, in Germany ... 17
The Value of. Alton D. Adams ... 277
The Commercial Development of. Alton D. Adams ... 361
Watson, Egbert P.:
Costly Amateur Electric Engineering ... 15
Webb, Herbert Laws:
The Telephone in the United States ... 49
Webb, H. S.:
The Increasing Use of the Telephone ... 431
Welding, The Widening Use of Electric ... 62
Western Union Telegraph Company, Annual Report of the. 475
Westinghouse Awards at the St. Louis Exposition ... 385
Westinghouse Electric & Manufacturing Company, Convention of District Managers of the ... 469
Wheeler, Schuyler S.:
The Electric Motor for Speed Regulation ... 459
Willey, D. A.:
Cooking with Electricity ... 392
Williams, Arthur:
Some Tests of Electric Motors and Other Figures ... 279
Wind-Mill Electric Plants. Hanford C. Judson ... 257
Winding Engines, Electric ... 78
Wiring and Equipment, Underwriters' Rules for Car ... 239
Wireless Electric Typewriter, A ... 33
Wireless and Submarine Telegraph, Completion ... 131
Wireless Telegraph:
War News by ... 130
Portable, Apparatus for War Service. Alfred Gradenwitz ... 282
Prospects ... 290
Earnings ... 372
International, Conference ... 389
British Naval Use of the ... 433
The Chicago-St. Louis, Tests ... 450
Wireless Telegraphy:
In the Russo-Japanese War ... 29
For the Navy ... 41
Transatlantic ... 144
At the St. Louis Exposition ... 161
The Effect of Electrical Storms on ... 191
The Largest Station for ... 289
Overland ... 371, 453
Wireless Telegraphic Communication with a Balloon ... 416
Wright J.:
The Development of the Galvanometer ... 30
Electrical Energy Direct from Coal ... 476
Wynkoop, Hubert S.:
Electric Fire Risks ... 59
Young, H. W.:
Electrolytic Meters ... 106

THE ELECTRICAL AGE

Established 1883

Volume XXXIII Number 1
$2.50 a year ; 25 cents a copy

New York, July, 1904

Entered at the P. O. as 2d-class matter. Copyright, Louis Cassier

Electricity in Farming

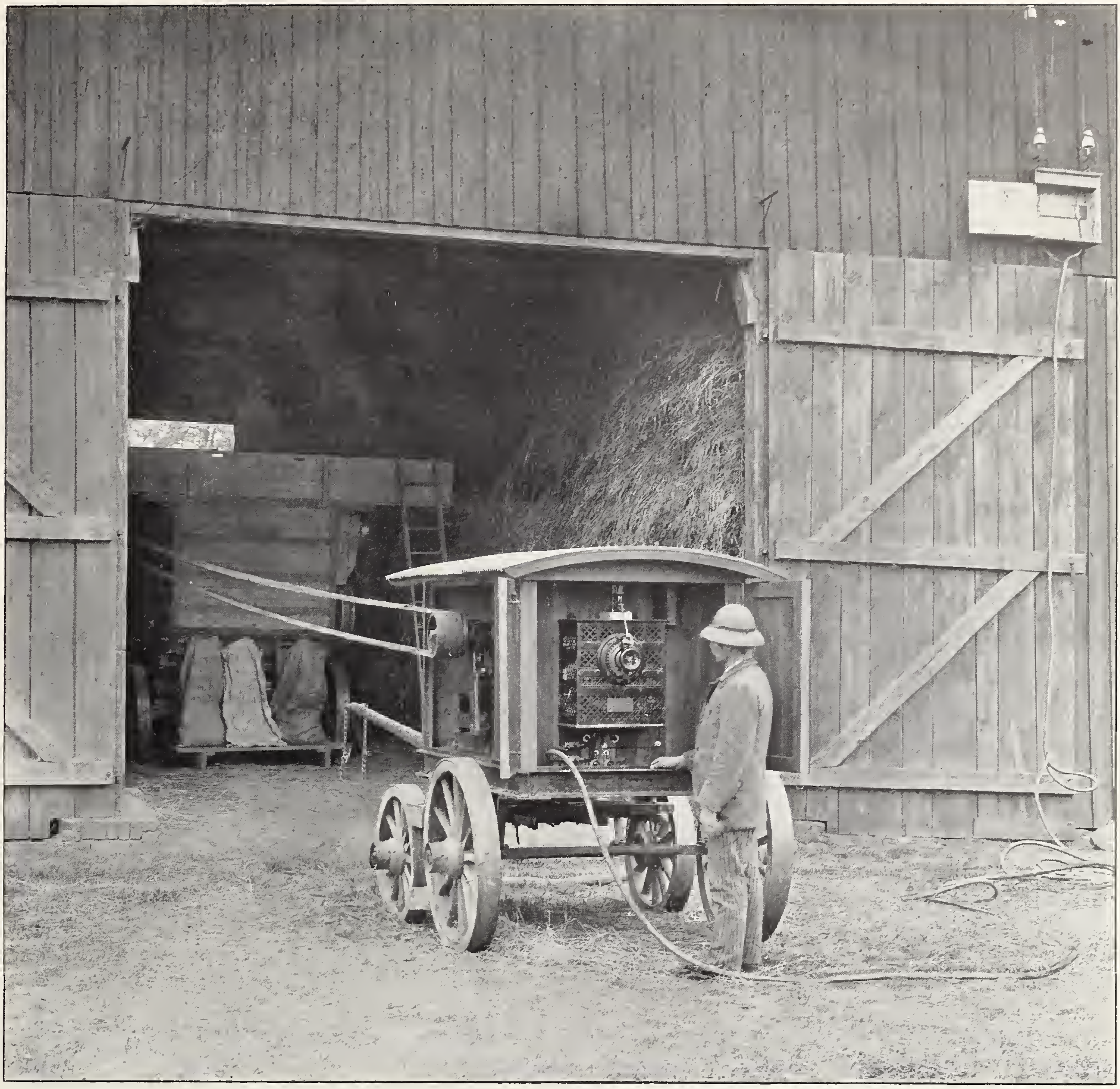
By HANFORD C. JUDSON

ELECTRIC POWER AS APPLIED TO PLOWING BY THE SIEMENS-SCHUCKERT COMPANY, BERLIN

THE possible application of electricity to farming is very broad, for recent experiments have shown that with the same methods of fertilization and culture the sugar in a crop of beats, for example, can be increased 15 per cent. when slight differences of electrical potential are maintained about their roots. The vegetable output of the world may be increased in this way, as it has been by scientific seed selection and by the careful adaptation of fertilizers to soil and crop; but the most pressing need in agriculture to-day is new means of lightening the manual labor on the farm, the plowing, mowing, garnering, baling, wood cutting, pumping and many other operations. For many years horse power, steam engines and oil motors have been applied to this work; but electricity has not been used extensively, though there are a few farms where the need of a large and constant amount of power, as in a big dairy, has made it the cheapest form of energy, because the most flexible, the most easily handled and the most reliable, and where its adoption has given great satisfaction.

Of such the Briarcliff farm, at Briarcliff Manor, on the Putnam Railroad, about 25 miles from New York, is a good example. Here there is not only a large dairy, but two hotels must

AN ELECTRICALLY DRIVEN THRESHING OUTFIT, INSTALLED BY THE SIEMENS-SCHUCKERT COMPANY, BERLIN

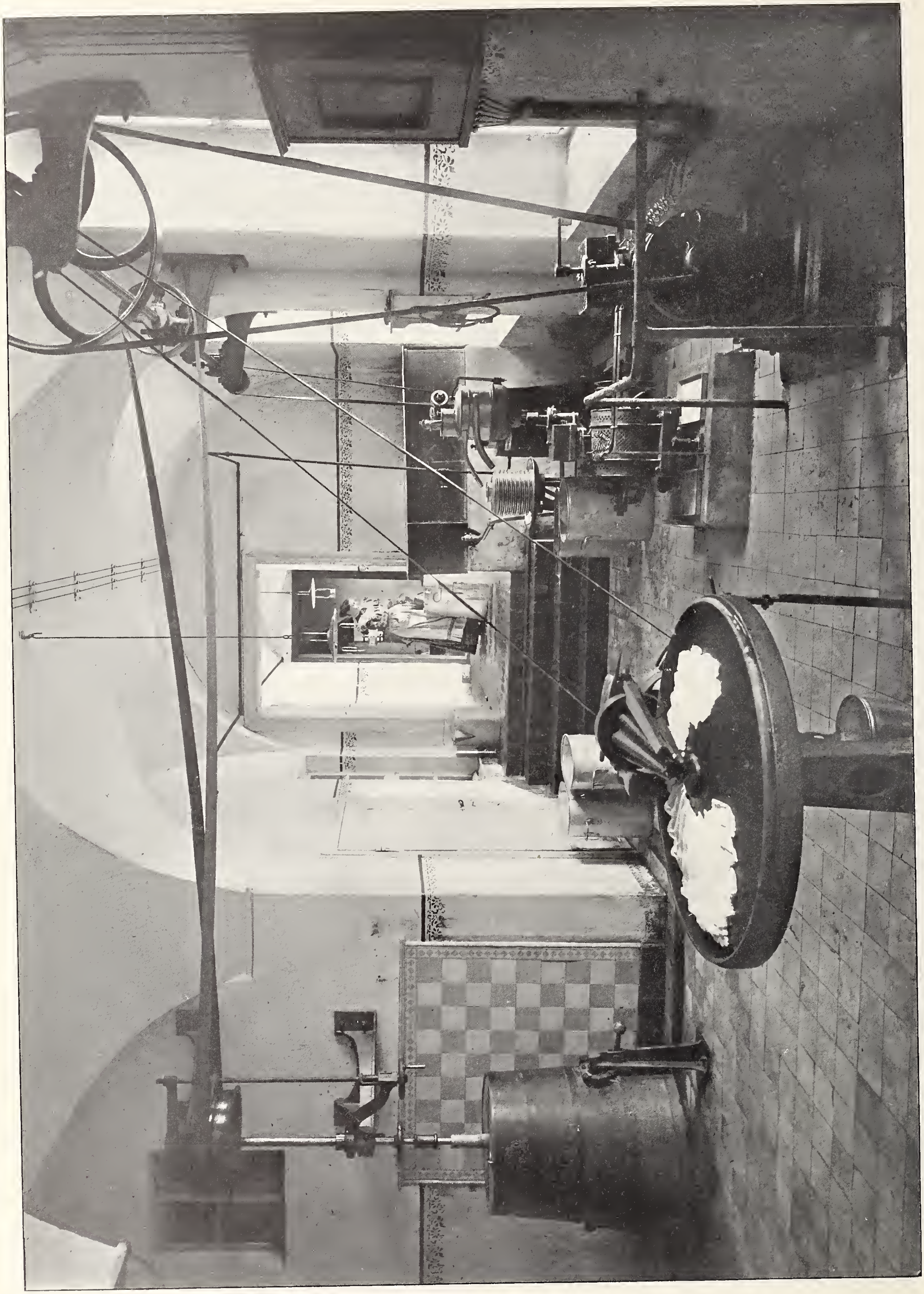


THE PORTABLE MOTOR AND ACCESSORIES

be lighted and supplied with electric power for elevators and blowers. An electric plant is there at once to be the natural solution of this problem in engineering economics. There is an element in it that is not agricultural; but if two or three neighbors who could have used electricity on their farms had joined to bear the expense of producing it, the amount generated would have been about the same and the cost per H. P.-hour about as low.

In a dairy like that at Briarcliff, cleanliness is one of the greatest advertising assets, and becomes a positive necessity with highly specialized and delicate cows. The stables, the cattle, the clothes of the attendants must be kept as wholesome as possible, and dirty engines and oil lamps are out of place. The airy, modern barns, well lighted day and night, are easily kept clean, so clean, in fact, that the odor of milk and hay is brought to one's nostrils as he passes along the road beside them, and tells him that the milk that comes from such barns is good.

The electric power for lighting the barns and driving the motors on the Briarcliff farm is furnished by two 75 K. W., two-phase, 220-volt generators, belted to compound engines, and, as the plant is like many another, it need not be described. In the dairy house there are two motors; one is of a fraction of a H. P. for driving a bottle washer, on which 900 bottles can be washed a day, eight at a time, and which displaces two little steam motors, each cleaning one bottle at a time. The other, a 20-H. P. motor, is used for driving five large machines, by means of a line of shafting. Three of these machines are in the churning room, where there is a churn, a butter-working machine and a cream separator, and two of them in the bottling room—a can scrubber and an ice crusher. Another motor is to be installed to run a wire rope transferring device to carry the cans to and fro between the milk depot and the loading platform of the dairy.



ELECTRIC POWER IN A GERMAN DAIRY

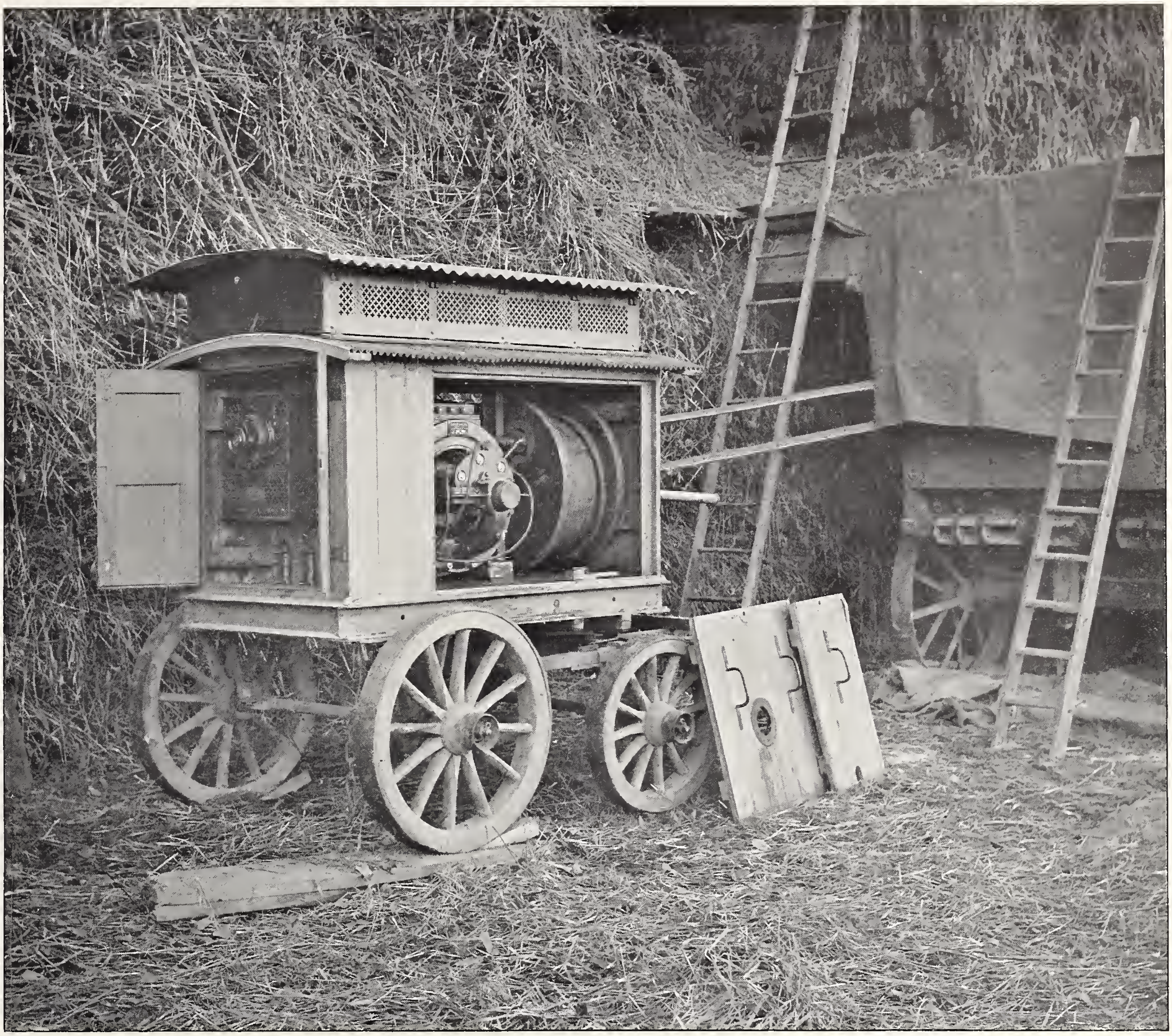
This, at present, is turned slowly and with hard work by two men. There is also a 20-H. P. motor in the laundry, driving two washing machines and a mangler.

For work about the farm, pumping, threshing, baling and stone crushing, a 20-H. P. motor is mounted on a carriage and is wheeled about and belted to whatever machine they desire to run.

The electrical input of each of these motors is measured by a meter in its circuit, and its running expense for energy and attendance compares very favorably indeed with the cost of doing the same work by steam. Nor is this surprising, for when the electric motor is once started, it runs without further attention, and one electrician can look after every motor on the place, while with the former method of steam driving, a skilled attendant was required at each machine while the work was going on. Then the portable engine and boiler was cumberous and was moved with difficulty, while the 20-H. P. motor on its carriage is light and can be taken from place to place with the greatest ease. Not only this, but the great danger from fire of having steam boiler near the barns is reduced to nothing by the electric motor, and the farmer is not bothered by the necessity of carting water and fuel and taking care of ashes.

The laundry and the dairy are near each other, and the problem of serving them with steam was very simple; yet even here electricity has proved itself to be more economical, and has the added advantage that the motor is out of the way, clean and noiseless. This, with the freedom from oily lamps, makes both buildings pleasing exhibits.

There are in the United States several dairies and farms, descriptions of which might nearly duplicate the above, both as to detail and success enjoyed. This indicates a fertile field for electricity in the farming country, not so much for small farmers as for groups of small farmers, and particularly in places where there is a water-fall at hand. The electric railways, which cross agricultural districts in New England and the Middle West, have another field which might be very profitably developed. Farmers might be induced to put in cheap temporary sidings from these lines to their barns to facilitate getting their



ANOTHER VIEW OF A PORTABLE ELECTRIC FARM MOTOR

produce to market, and when once the electric current is brought into the yard, it might safely and easily be extended to the fields and used for all manner of mechanical operations.

At reasonable rates for the energy it would be cheaper than the use of steam or manual labor, and would have the further advantage of giving sureness and quickness to the work of preparing the ground and of getting the crop safely garnered at the right moment. The planter could get the full advantage of his crop by waiting till it was at its best, confident that, when the golden moment came, he would be able to get it in before it deteriorated. This would be electricity's greatest advantage on sugar plantations, for the cane crop deteriorates very fast under exposure on being cut, and also when it is left standing after it has reached its critical development.

If, on the large plantations, the steam locomotive-propelled trains of flat cars could be displaced by electrically-driven trains running on temporary tracks from the cane cutters to the grinders, there would be gained not only the advantage of quick transportation, but, with so applicable a form of energy as electricity at hand, it would not be hard to devise means of using it to facilitate the loading and unloading, and even the cane cutting.

As for the use of electricity abroad in farm work, the Societe Helios of Cologne has installed some very interesting plants for agricultural purposes at Summern, Quednau and Crottorf, in Germany. At Summern there is a water-driven turbine connected to an 11-K. W. 110-volt generator supplemented by a storage battery to help carry the heavier loads. On this farm but two motors are used, a three-quarter-H. P. for driving a cream separator and a 10-H. P. portable motor on a carriage that may be wheeled about to the different agricultural machines.

These machines have been grouped in such a way that several of them may be driven at once, insuring economy in operating expenses and making the use of more than one motor unnecessary. The motor may be taken to one room, and by a few feet of shafting be made to drive a carrot cutter, cuting 1430 pounds of carrots an hour, a machine for crushing cakes of linseed at the rate of 1100 pounds an hour, and a pump able to lift 353 cubic feet of water an hour to the stables. In another place it is used to drive a threshing machine and at the same time a straw cutter, giving 330 pounds an hour.

At the Quednau farm, about 300 acres in size, and from which about 2600 gallons of milk are sent daily, there are two steam engines driving direct-current generators, one a 45-K. W., 500-volt machine, and the other a 6.6-K. W., 220-volt machine, and in conjunction with these a storage battery. At night the engines are shut down, and the battery, which has been charged during the day, is used to light the farm and furnish what power may be needed. For charging this battery, the 6.6-K. W. machine is driven to give 18-amperes at 320 volts.

On this farm there are three motors: one, a $2\frac{1}{2}$ H. P., drives a carrot-cutting machine and a straw-cutter; another, a 15-H. P. portable motor, is used for threshing, driving a circular saw, pumping and milling. The third is also portable, but is usually kept in the grainery, where it drives a mill. Besides these there is an electric plow which is driven by two motors on wagons, one on each side of the field, and which, by means of wire cables, draw it back and forth. This plow will break up very hard soil, and cuts 13 inches deep through it. Its speed can be regulated to 10 per cent. of full speed by a resistance, and it passes from one furrow to the next almost automatically by means of two switches. At Quednau, which is comparatively a small enterprise, the motors replace twelve horses and eight men.

The third station is at Crottorf, in Saxony, and covers one of the most fertile districts in Germany. Its position is nearly at the center of a farming district 18 miles in diameter, and in which there are twenty-seven towns. The electric power is obtained from a water-fall in the Bode River by three turbines geared to a common shaft to which is direct-connected a 500-K. W., three-phase, 7000-volt alternator. This shaft is arranged so that it can be driven by a steam engine, coal being easily obtainable from neighboring mines. Another steam engine, connected to a similar generator, 500-K. W., supplements the plant; but the water-power is usually sufficient to supply the demand. The steam engines are able to carry the entire load when the water-power gives out.

In each of the towns supplied by this plant there are transformer sub-stations and rotary converters which distribute the energy at low voltage. These sub-stations are supplemented by accumulators, charged during the day, and assisting the converters at night. In the larger towns, where both the lighting loads and the fluctuating power loads are heavy, separate circuits for lighting and power are used; but in small towns, where there is only a light load, one circuit is used. One of the most interesting features at Crottorf is the portable transformers for taking energy from the high-potential circuits in the field, at any spot where connections can be made, and delivering it at low voltage for power to drive agricultural machines.

Electric Power from Shawinigan Falls in Canada

CARRYING a 50,000-volt current a distance of 85 miles and delivering in the neighborhood of 10,000 H. P., as is done in the case of the Shawinigan Falls electric plant in Canada, is an engineering achievement of the first magnitude and importance in even these days of remarkable electrical undertakings. The Shawinigan plant, in fact, demonstrates perhaps a bit more strikingly than most others of allied character, what remarkable results in the development of a certain locality may be reached by a judicious exploitation of its power riches, for Shawinigan, to-day a city of rapidly widening limits and growing manufacturing interests, was practically non-existent four years ago, when the canoe was the only means of access to the place. The electrical part of the enterprise was carried out by Mr. Ralph D. Mershon, as consulting and supervising engineer, and represents the fulfilled promise of excellent work to be done which was given by his earlier attainments in high-tension transmission engineering. The installation, as it stands to-day, delivering current principally to the city of Montreal, is one of the best existing examples of what may be hoped for from hydraulic and electrical engineering skill combined in the face of great difficulties to be overcome.

According to a paragraph now making the rounds, a German has recently discovered a tree in Central India with leaves so full of electricity that whoever touches one of them receives an electric shock. The electrical strength of the tree varies according to the time of day, it being strongest at midday and weakest at midnight. In wet weather its powers disappear altogether. Birds never approach the tree.

It is reported that an Italian engineer named Nisco has devised a new photometer. It consists of a selenium cell, which, when exposed to the source of light to be tested, changes its resistance. It is stated that the resistance may vary by 10,000 ohms between darkness and full illumination.

The Choice of a Steam Plant

With Special Reference to Electric Power Installation

By GEORGE H. BARRUS

THE STEAM TURBINE.

INTEREST in the steam plant, and in the choice of engines and boilers for electric power generation, has been widely increased by the introduction of the steam turbine, and there is no department of engineering which is receiving more attention at the present time on this account than that of steam engineering. The subject has attracted more notice than ever during the past year, and particularly on account of the development of the Curtis turbine.

No one can now discuss matters regarding the selection of a steam plant, especially in electric circles, without becoming aware that the steam turbine has obtained a strong foothold, and it must be considered, along with the various kinds of reciprocating engines, as one of the sources of steam power from which to make a selection. In this connection it is significant, as showing the trend of engineering thought and development, that one of the largest and most widely-known builders of reciprocating engines has recently embarked in the turbine business, and that there are no less than four types of turbines on the market, made by responsible firms.

Until recently engineers familiar only with reciprocating engines had great doubt as to the ability of the steam turbine to compete with a reciprocating engine in the matter of steam economy; and there are many who still cling to the belief that the turbine principle must be a wasteful method of generating power. Reports of late investigations on different kinds of turbines, made by different engineers who are wholly unbiased, leave little room for doubt, however, that the turbines in their latest and best forms are not only far from being wasteful, but, as a matter of fact, their economy in steam consumption is equal, if not superior, to that of the best classes of reciprocating engines in common use in electric power stations.

There are numerous advantages possessed by the steam turbine, which are exceedingly attractive to the purchaser of a steam plant, and to the operator as well, and now that the turbine business has reached a stage of successful development, it is not surprising that the turbine manufacturers are favored with a large amount of business. At the same time, there are points about the turbine which are less attractive than those noted, and these make the engineer question what the ultimate status of the machine will be after it has been subjected to the wear and tear of ordinary electric power plant service.

It must be conceded that the turbine is still in what may properly be termed the experimental stage, although giving promise of an excellent future, and it would be unwise, if not impossible, in a popular discussion of the subject, such as may be attempted in this article, to make a comparison of the different makes, or to offer any suggestions as to matters which should govern the choice of a turbine, in case the purchaser of a plant should decide upon this form of motive power. The purchaser himself is the only one who can settle this question, after having made a careful examination of the present status of the different types presented for a choice.

THE RECIPROCATING ENGINE.

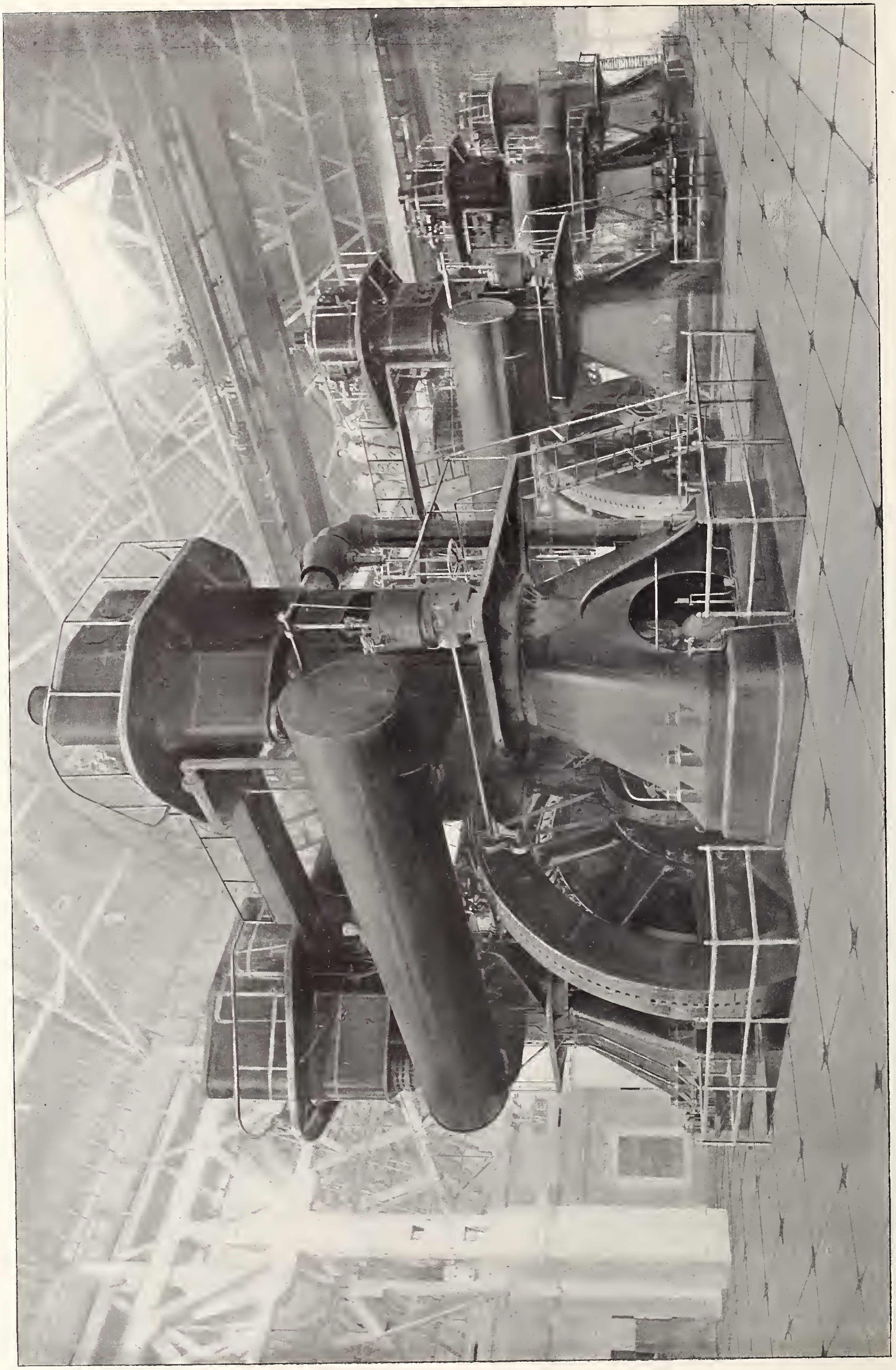
In the matter of choosing a reciprocating engine for an electric power plant, it is noteworthy that in nearly all of the larger and more important electric plants which have recently been installed in the United States, the engines adopted are those of the well-known Corliss type. The fact is notable because the character of the motive power in these plants has been decided upon only after the most searching examination, in which the subject is studied in all its bearings and viewed from every standpoint. It is to be noticed also that not only in the newer and more modern stations, but also in the older plants of the larger sizes, the Corliss engine is the most widely used. It is probably not too much to say that in the larger stations there are a greater number of these engines driving electric generators than on all other kinds of engines combined.

The features which distinguish the Corliss engine from engines of other types are the form, arrangement, and mode of operation of the valves. If this engine is more popular, therefore, than other engines, the reason lies primarily in the popularity and success of the Corliss valves and of the mechanism employed in operating them, rather than in any other particular.

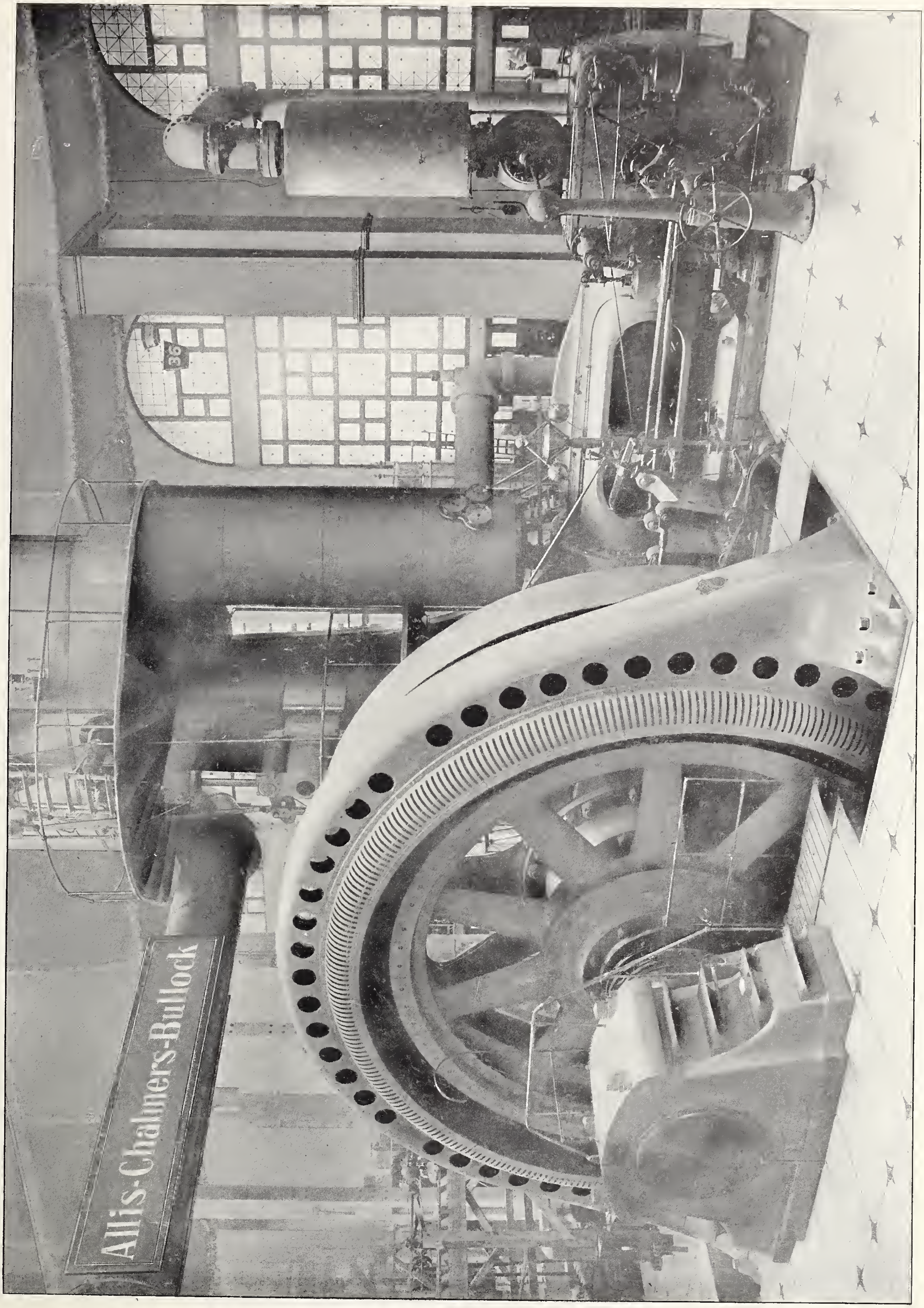
Corliss valves have many advantages which justify their excellent record. One of the advantages which is greatly appreciated by the operating engineer is the accessibility of the valves for examination and repair. Being cylindrical in shape and lying in a cylindrical chest of small diameter, the bonnets which cover the ends are of small area. Indeed, they are so small that four bolts suffice to hold one in place. To uncover the chest for the purpose of removing and examining the valve, it is necessary, therefore, to remove only four bolts, and this can be done not only with the greatest ease, but with the least expenditure of time. Another thing which adds to the ease of removal is that the valve is withdrawn from the chest endwise through the rear opening, and the connection between the driving end of the valve and the mechanism is such that the removal takes place without disturbing the mechanism in the least.

Accessibility in an engine valve is of little avail, however, unless the valve and its seat can be easily repaired. The Corliss valve is not only accessible, but its cylindrical form enables it to be most readily turned in the lathe and refitted when it becomes worn. The seat, being also cylindrical, is most easily rebored when the wear of the surface makes it necessary.

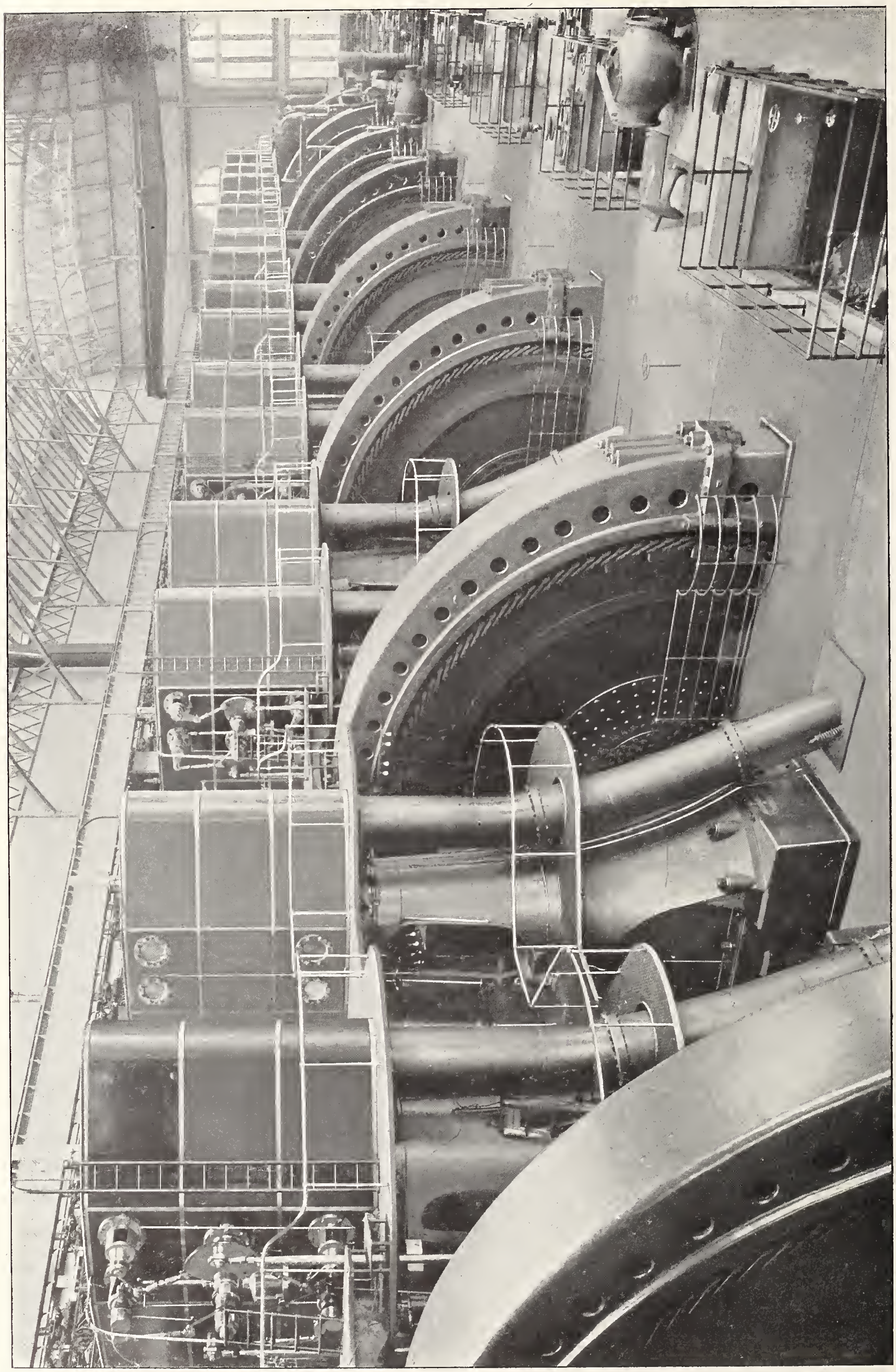
Another advantage of the Corliss valve is its durability and its tendency to maintain a steam-tight condition in service. The valves have considerable lap, and for this reason the wear of the lapping surface occurs at a slow rate, and excessive leakage appears only after a long period of service. The use of independent steam and exhaust valves, the location of the exhaust ports and valves in horizontal cylinders at the bottom where best drained, the simplicity and accessibility of the



FOUR WESTINGHOUSE CORLISS CROSS-COMPOUND ENGINES, EACH OF 3500 I. H. P., AT THE ST LOUIS EXPOSITION. EACH IS DIRECT CONNECTED TO A 2000-K. W. GENERATOR. DIAMETER OF HIGH-PRESSURE CYLINDER, 38 INCHES; DIAMETER OF LOW-PRESSURE CYLINDER, 76 INCHES; STROKE, 85 INCHES. SPEED, 85 REVOLUTIONS PER MINUTE



THE ALLIS-CHALMERS COMPANY'S 8000-H. P. STEAM ENGINE AT THE ST. LOUIS EXPOSITION, KNOWN AS "BIG RELIABLE." DIAMETER OF HIGH-PRESSURE CYLINDERS, 44 INCHES; DIAMETER OF LOW-PRESSURE CYLINDERS, 96 INCHES; STROKE, 60 INCHES. THE BULLOCK GENERATOR TO WHICH THE ENGINE IS COUPLED IS OF 3500 K. W.



THE POWER HOUSE OF THE MANHATTAN RAILWAY COMPANY, NEW YORK. THERE ARE EIGHT DIRECT-CONNECTED UNITS. THE GENERATORS ARE WESTINGHOUSE 5000-K. W. MACHINES, 11,000 VOLTS, THREE-PHASE. THE ENGINES ARE COMPOUND DUPLEX, OF 8000 H. P. EACH, COMPRISING TWO 44-INCH HORIZONTAL HIGH-PRESSURE CYLINDERS AND TWO 88-INCH VERTICAL LOW-PRESSURE CYLINDERS. STROKE, 60 INCHES. BUILT BY THE ALLIS-CHALMERS COMPANY, MILWAUKEE WIS.

valve mechanism, and the ease with which the mechanism is adjusted, are added advantages, which, one and all, have done their part in making the Corliss engine popular among engineers, and most serviceable in practice.

The mechanical features noted are not the only ones which distinguish the Corliss engine and give it high standing. It is also most economical in the consumption of steam, and this advantage is always recognized as one of the greatest importance. The economy realized in operation is the direct result of the notable points of design which mark the Corliss construction. One of these, which takes a leading place, relates to the efficiency of the valve mechanism and releasing gear. These operate in such a manner as to secure a highly effective distribution of the steam; that is, the admission, cut-off, release, exhaust and compression of the steam in its passage through the cylinder are made to take place at the proper times to secure the most economical work. That the distribution is well carried out, is shown by the form of indicator diagrams taken from the Corliss engine. These present such excellent features as to leave little room for improvement.

The design of the Corliss valve and its location close to the bore of the cylinder, as well as near to the end of the stroke, reduce the clearance passages to small volume, and furnish another reason for the economy of the engine. Still further reason for economy is the fact, already noted, that the form of the valve is favorable to tightness, and, not only this, but to a maintained tight condition for long periods. Excellent steam distribution and small clearances are of little avail in securing economy in an engine, unless tight valves and pistons go with them, and these are not wanting in Corliss engines which are properly handled. The economy in steam consumption which is obtained by the Corliss design is well proved by actual tests in practical operation. No engine, in the writer's experience in testing, gives better records.

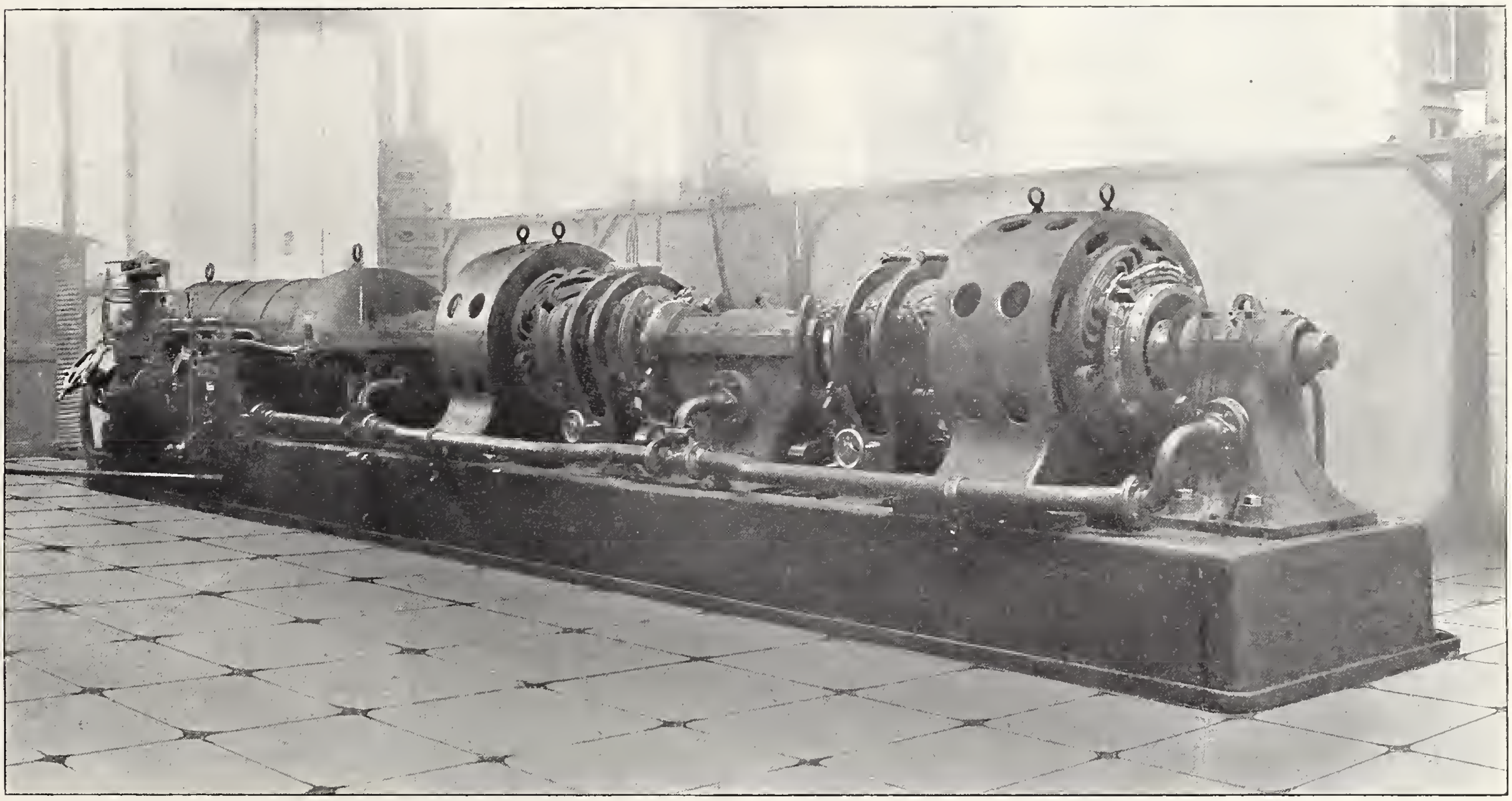
One of the latest designs of the Corliss engine which has been adapted to electric work, where large power is required, consists in the use of a pair of engines, each of which has two cylinders, one being horizontal and one vertical, working on the same crank-pin. In these engines, which are of the compound type, the high-pressure cylinders are those which are horizontal, and the low-pressure cylinders, being the larger, are the ones placed vertically. This arrangement is especially suited to electric generators, because of the uniformity of rotation produced and the consequent uniformity of the current.

The impulses due to the working of the steam are distributed in eight parts about the circumference of the shaft, and produce an almost continuous propelling force, whereas in the simple engine there are only two impulses per revolution, and the momentum of the fly-wheel and of the rotating parts of the generator is depended upon to keep up the speed while the crank passes the two dead points. Uniformity of rotation is of special advantage in alternating-current work where a number of engines and generators are required to run in parallel.

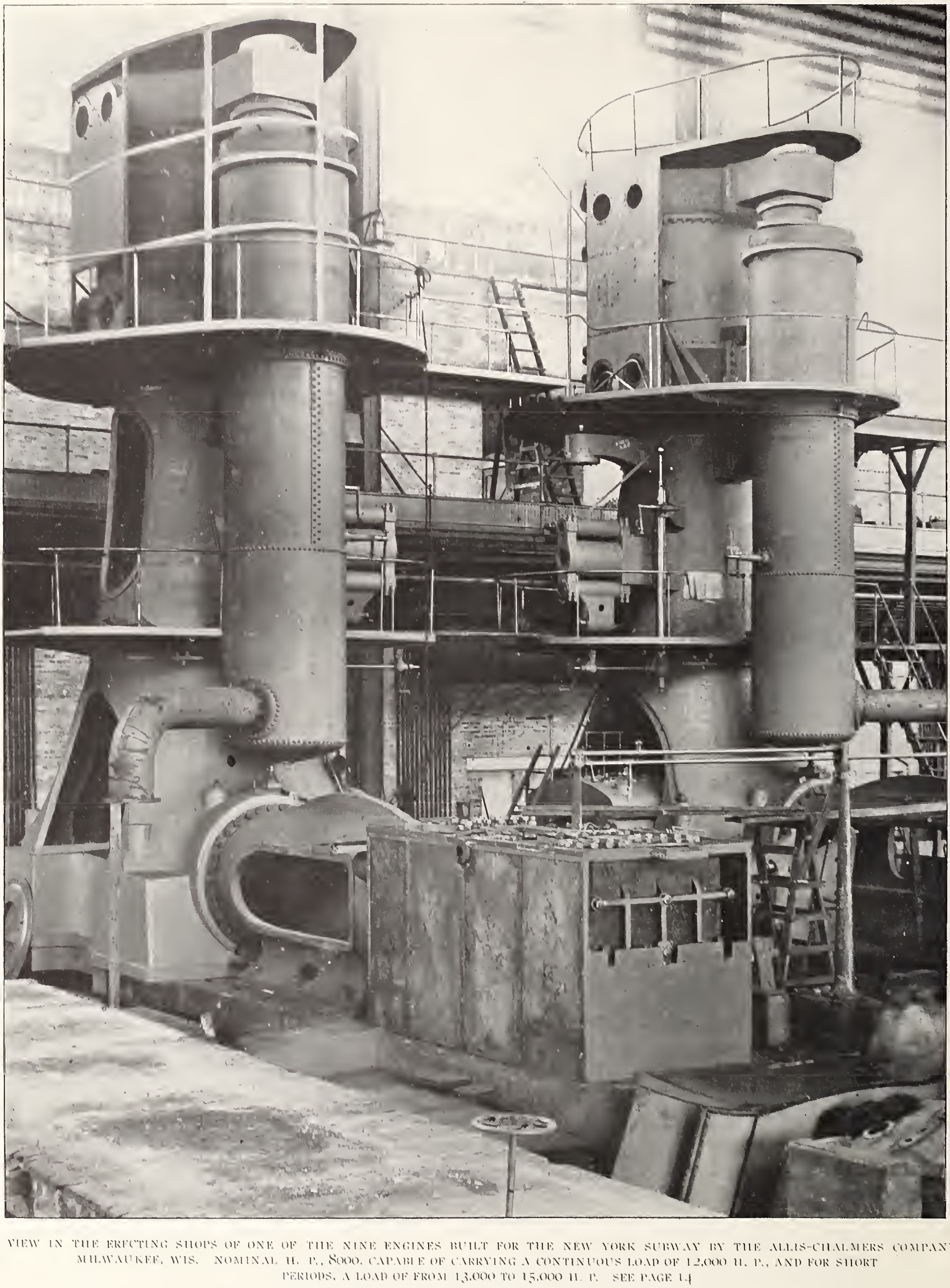
The compound condensing engine is a type that is now almost universally selected for large central stations. Between this and the triple or quadruple expansion engine, at existing pressures, there is little choice on the ground of economy, and the greater simplicity of the former is an advantage which easily gives the compound engine first place. This class of engine requires no unusually high grade of talent for its successful operation, and it furnishes a motive power which can in all respects be depended upon.

Comparatively few modern engines, even of the larger sizes, are steam-jacketed, as the increased economy due to jacketing has often been found so small as to hardly justify the necessary increase of cost and complication. Reheating receivers are in frequent use, being chiefly beneficial in producing a greater amount of power in the low-pressure cylinder, and thereby adding to the capacity of the entire engine.

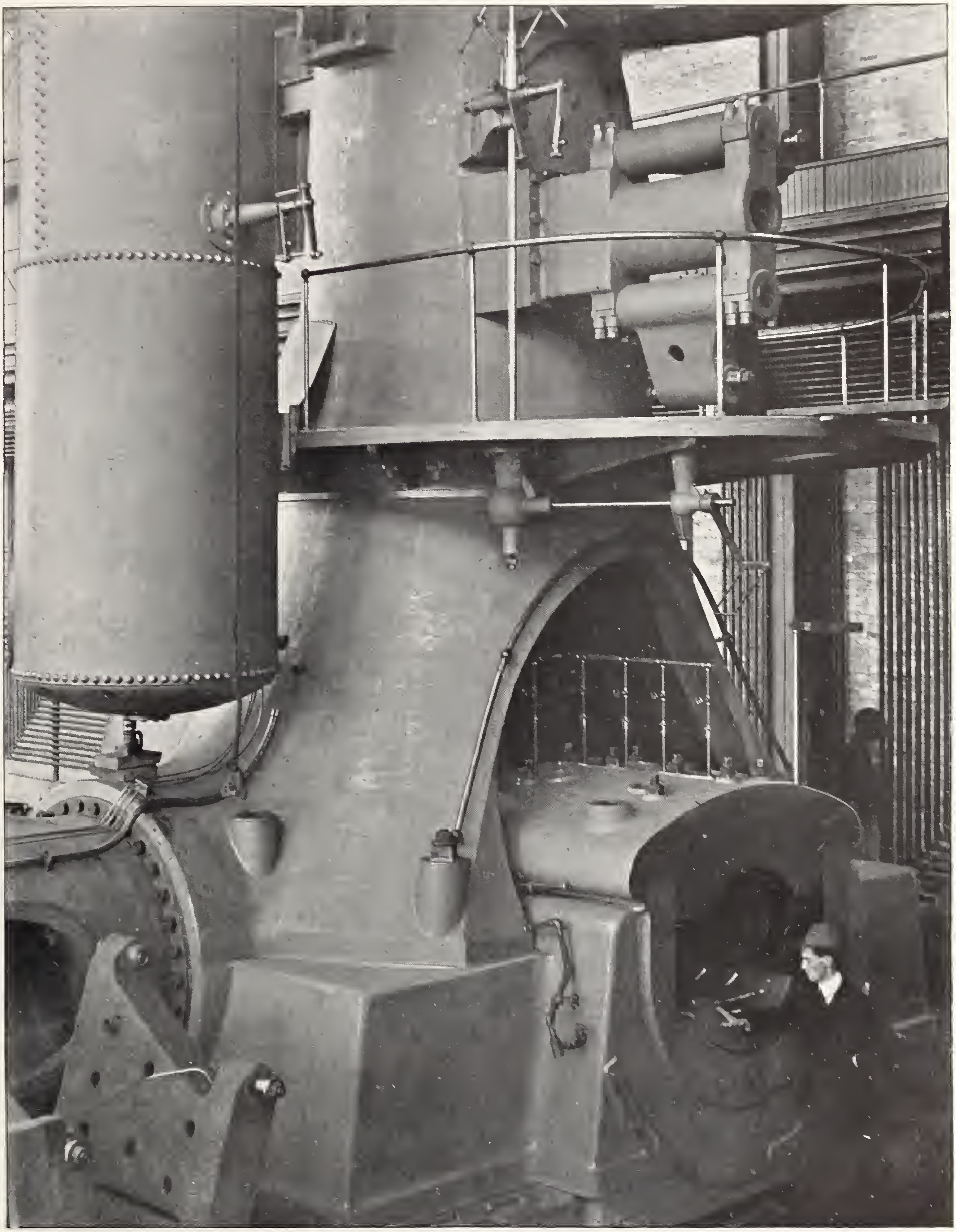
Jet condensers with independent air pumps, either steam-driven or electrically-driven, are the most popular, and



A 420-H. P. TURBINE, DIRECT CONNECTED TO TWO DIRECT-CURRENT GENERATORS. BUILT FOR THE FRENCH NAVY DEPARTMENT BY MESSRS. BROWN, BOVERI & CO., BADEN, SWITZERLAND



A VIEW IN THE ERECTING SHOPS OF ONE OF THE NINE ENGINES BUILT FOR THE NEW YORK SUBWAY BY THE ALLIS-CHALMERS COMPANY, MILWAUKEE, WIS. NOMINAL H. P., 8000, CAPABLE OF CARRYING A CONTINUOUS LOAD OF 12,000 H. P., AND FOR SHORT PERIODS, A LOAD OF FROM 13,000 TO 15,000 H. P. SEE PAGE 14



THE ALLIS-CHALMERS NEW YORK SUBWAY ENGINES. ONE OF THE MAIN BEARINGS. EACH ENGINE HAS FOUR CYLINDERS GIVING EIGHT IMPULSES PER REVOLUTION THE RESULT IS AN ALMOST PERFECT ROTATIVE EFFECT

the loss of steam due to using the steam-driven type is largely prevented by passing the exhaust steam through a heater and utilizing it for heating the feed-water for the boilers. Superheated steam is being introduced in electric power plants to some extent, but the question of its desirability and economy as to coal consumption has not been proved with that degree of satisfaction which is convincing to all steam users.

THE BOILER.

Turning from the engine question to that of the selection of boilers for electric plants, reference may again be made to what has been successfully accomplished by some of the leading power stations, for their practice in boiler engineering, as well as in the matter of engines, carries much weight. One of the first large electric power stations of any note installed in the United States,—the Albany Street power house of the Boston Elevated Street Railway Company,—built about twenty years ago under the engineering supervision of Mr. F. S. Pearson, adopted the horizontal water-tube boiler of the Babcock & Wilcox make. Four or five years ago, when the same engineer designed the Metropolitan Railway Company's power station in the city of New York, Babcock & Wilcox boilers were again adopted. In the Manhattan Railway Company's station at Seventy-fourth Street and East River, New York, which began operations two years or more ago, no less than 32,000 H. P. of these boilers are in use under one roof. Other large stations recently erected, and some in process of installation, to say nothing of many smaller plants, have adopted boilers of similar make. Whatever merits may be possessed by water-tube boilers of other makes, or indeed of any type of boiler, it appears certain from this array of examples that the Babcock & Wilcox boiler has characteristics which entitle it to no small consideration for use in electric plants, and a purchaser cannot go far astray if he makes this his choice.

The reason for the wide use and evident adaptability of this form of water-tube boiler to electric work is not found in any one conspicuous merit, but, as in so many other successful appliances, it must be attributed to the "all-around" satisfaction which the boiler gives in service, and the fact that it successfully meets the varied requirements of electric power stations.

In the matter of withstanding the high pressures which the steam engine practice of the day demands, there is little question in the mind of either the owner or the engineer that this boiler has the highest degree of safety.

The largest shell which is commonly exposed to pressure is only 42 inches in diameter, this being the steam drum, and no difficulty exists in making it of ample strength. What is of greater importance, this shell, being removed from the direct action of furnace heat, is free from the special deterioration to which boilers are subject which have riveted plates exposed to the fire; and the need of reducing the limit of safe pressure as the boiler grows old does not exist to that extent which is experienced in externally-fired shell boilers.

The boiler in question is of simple design and construction, and there are no points about it which are not readily comprehended by the ordinary fireman and engineer. Absence of complication is of the greatest importance where such rough usage occurs as that going on in connection with boiler operation. In the care and daily handling of the boiler, it does not require to be favored, for it responds to any demands put upon it, however strong the draught and however much the fires are forced. When called upon to do so, it develops far beyond its rated capacity in power. The area of the surface at the water-line is so large that no unusual attention to the supply of feed-water is required, and the water-tender has an easy task in avoiding either high water or low water.

Every necessary provision exists for keeping the heating surfaces clean either of soot or of scale. The former is accomplished by blowing the exterior of the tubes with a steam jet, and the latter, by scraping or otherwise cleaning the interior. When the tubes wear out, thay can be readily replaced with new ones, and the feature of easy repair in this respect is one of the strong points appealing to the operating engineer.

The tendency in the design of modern power stations is in the direction of using large-sized boiler units, and the boiler under consideration meets the demand. Units of 500 H. P. are widely employed, this size being about as large as it is convenient to use with the ordinary arrangement of grates, which become more and more unwieldy as the size increases.

No boilers in the large modern power stations are thought to be complete, unless fitted with automatic stokers and coal-handling machinery. When the stoker is of good design, and properly attended, it not only saves fuel, but if used in connection with coal conveyors, it also saves a part of the boiler room force of firemen and laborers. In large stations, where the problem of labor is apt to be a serious matter, such aids are not only desirable, but well-nigh indispensable.

Another adjunct to the boiler plant which is found in most of the large central stations is the apparatus commonly called an "economizer," placed in the chimney flue, for heating the feed-water. The utility of the economizer depends, to some extent, on the temperature to which the water is first raised by the drips and the steam exhausted from the auxiliaries.

Under the most unfavorable conditions, however, the advantage derived from recovering the waste heat of the gases is sufficient to make a considerable saving of fuel, and the money value of the saving represents a profitable return on the investment, except in localities where low-priced coals are available.

In closing this article, the writer would not have it understood that because the particular types of reciprocating engine and water-tube boiler named are so popular and successful for electric work, they should necessarily be selected by the purchaser of a plant if he would insure satisfactory results. The desirability of other types of engines and boilers cannot thus be underrated. The fact is that many electric plants are in successful operation in which the engines have not the least resemblance to a Corliss design, and the boilers are of such different types from the horizontal water-tube class that they would hardly be recognized by a layman as being designed for the same purpose. Just what engines and boilers, and the various appurtenances which go to make up the complete plant, should be selected in any particular case can be decided only after all the circumstances are fully considered.

Engines for the New York Subway

THE engines built for the operation of the New York subway of the Interborough Rapid Transit Company by the Allis-Chalmers Company, of Milwaukee, Wis., are nine in number, one of them, as photographed in the erecting shop of the builders at West Allis, near Milwaukee, being shown on pages 12 and 13 of this issue.

These engines are practically duplicates of the eight engines now in operation in the power house of the Manhattan Elevated Railway, Seventy-fourth street and East River, New York. These engines, while nominally of 8000 H. P. each, are actually working in everyday service at about 10,000 H. P. and are guaranteed to carry a continuous load of 12,000 H. P., while in actual service they have occasionally, for short periods, developed from 13,000 to 15,000 H. P.

They represent probably the simplest form of large engine that has ever been built, there being but two crank-pins and two main journals, thus obviating all questions of shaft alignment and the troubles due to the marine type of double-throw cranks, which have heretofore been used on all large engines. Another advantage of this type of engine is the almost perfect rotative effect, there being eight impulses per revolution, due to the employment of four cylinders operating on two cranks set at proper angles.

Another feature of these machines, which is not ordinarily understood, is the ability to obtain practically the same economy at one-half load as at full load. This is accomplished by practically closing the throttle on one high-pressure cylinder, admitting merely steam enough to that side of the engine for the purpose of lubrication and the maintenance of the vacuum on the low-pressure cylinder, running the other side of the engine with the throttle wide open and working at the point of maximum economy. When the load increases it is only necessary to open the other throttle without making any other changes or adjustments, or disturbing the operation of the engine in any way.

These engines operate perfectly in parallel under any and all circumstances, and have been subjected to the most severe tests in the way of short circuits, heavy overloads, etc., during the two years they have been in operation, and have come through unscathed. The high-pressure cylinders are 44 inches in diameter and the low-pressure cylinders 88 inches, the stroke of all being 60 inches. The speed is 75 revolutions per minute.

Costly Amateur Electric Engineering

By Egbert P. Watson

A MAN conceived the idea of installing electric lights in his country house, and, not having a great deal on his mind, thought it would be a very simple thing to occupy his leisure in this way. To this end he applied to a firm of engineers, laid before them his requirements, and asked what they would undertake the work for. They named a sum which seemed to him an exhorbitant one.

"It cannot possibly amount to any such figure," he reflected, and, to satisfy himself upon this point, began inquiring around among manufacturers for the different details. The dynamo was quoted at so much by one firm, but another one bid much lower; so, without any knowledge of the capacity of the two kinds, he decided that the cheapest was the best, and ordered that.

The engine was the next thing, and he purchased one "guaranteed" to do certain things, but he did not bother with investigating the guarantors; for there is much virtue in a guarantee—like charity, it covers a multitude of sins. The same course was pursued with other details, including the boiler, the projector of the scheme here outlined being apparently of the opinion that setting up an electric light plant was akin to ordering furniture from a department store and arranging it to suit his views of what was proper under the circumstances.

Collecting the several details was an affair of many months, for with no one behind the purchaser to see that the promises made for delivery were kept, and protected by advance partial payments against the orders being countermanded, the sellers took their time, and the buyer learned a lesson in patience under difficulties.

Everything has an end, however, though the upshot of the matter was a misfit all around, as might have been expected under the circumstances. The boiler was too small for the work to be done, though it was what the buyer had called for. He had specified one of 25 H. P., but under ordinary load and pressures the engine worked up to as much as 35 H. P. Moreover, when complaint was made that the boiler was inadequate, the maker declared that it was based on standard requirements and would deliver its rated H. P. with proper care and management if the engine were also of standard rating. Whereupon the owner was moved to say that the latter was all right, it being guaranteed to deliver a H. P. for "56 pounds of water" per hour. The response to this was that the boiler was too small by 50 per cent. if the engine required that amount of steam per hour per H. P. and that it was not the boiler maker's affair. The rest of the outfit was burdened with troubles of similar nature.

In the interval which transpired between the inception of the plan and its final execution great improvements, moreover, had been made in electric lighting plants, so that if everything had really worked as it should, the man still would have had an obsolete outfit. The natural reflection is that the man was unwise; for in cases like the one related it is not only the first step which costs, but all the subsequent steps as well. A reliable firm of engineers would have given him perfect satisfaction in the premises, and he would have had value for his money.

Egyptian Markets for American Electrical Machinery

EVERY indication, says "The American Machinist," points to the fact that electric lighting is becoming more and more popular every day in the principal towns in Egypt. Most of the large German electrical firms are represented throughout the country, and of late years they have been fairly successful in securing some very good contracts. They quite naturally oppose very energetically the entrance of any likely competitors.

The French Gas Company at Alexandria supplies most of the power employed, and they have obtained a long lease of the right for many years. There are, however, a good number of British and German dynamos employed in various establishments and private houses.

There is a steady demand for electric fans; the bulk of this trade is now in the hands of American firms. The most popular fans, which find the quickest sale, measure 12 to 15 inches in diameter, revolve under a current of 100 volts and make 400 revolutions per minute. They can also be regulated to three speeds. The prices vary from $20 to $25 each, delivered c. i. f. Alexandria, duty paid. It would certainly be well worth the while of American manufacturers to study the wants of the Egyptian market in this as well as in other lines of hardware and machinery, there being a capital opening in the principal towns.

That portion of the St. Louis Fair known as the Philippine Exposition has been made the subject of a descriptive pamphlet recently sent out by the Philippine Exposition Board. The illustrations will give the reader an excellent idea of the physical peculiarities of the Filipino as well as some knowledge of his method of living. The principal features of the exhibit as well as of the islands themselves are described at some length.

A stock company with an authorized capital of $482,500 has been organized at Milan, Italy, for the purpose of utilizing the water power of the province of Liguria for an electric plant.

Prices of Electrical Energy in Bulk

By ALTON D. ADAMS

LARGE factories, electrical supply systems and street railways are now operated, in many cases, with purchased electric power. This practice is a result of the construction of highly efficient, steam-driven electric stations, the electrical development of water powers, and of long transmissions.

Sales of electrical energy in bulk may be made either by a great water power and transmission system or by a distribution plant; but in either case the prices charged are quite certain to be far below those paid by the ordinary consumer. Even for sales of electrical energy in bulk—that is, on a great scale to single purchasers, there are large differences in the rates made by transmission and supply systems. Such differences rest in part on cost of production, but are often regulated in no small degree by what the traffic will bear.

Few kinds of service vary more in cost according to the conditions under which they are rendered than does electrical supply in bulk, and in order to draw general conclusions from particular rates it is necessary to know the main factors that bear on each particular case. For this reason the conditions under which the following rates were charged for electrical energy in bulk are stated somewhat in detail:—

In one of the larger cities of New England where the local electrical supply system draws its energy almost entirely from water power, current is sold to a great textile plant at the rate of approximately 1 cent per K. W.-hour for power purposes. The average consumption of energy by the electric motors in this plant is between 700 and 800 K. W.-hours per day. All of these motors are of the three-phase induction type, and alternating current is delivered to the plant at about 2300 volts. This textile plant is by far the largest consumer connected to the electrical supply system, and separate circuits are run to it from the sub-station.

In another large city of New England, where coal comes by rail, and the electrical supply system operates entirely with steam power, a textile factory draws current from that system for 500-volt direct-current motors of more than 600 H. P. total capacity. For energy used by these motors the rate charged is less than 4.4 cents per K. W.-hour. The steam-driven station that develops this energy operates with compound engines and draws water from a nearby river at slight expense for condensing purposes.

A certain municipal electric plant in Connecticut sells current for a continuous consumption of 50 H. P. in motors at 2.53 cents per K. W.-hour, and manufacturing industries are said to have been attracted to the town by the low power rate. This municipal plant is steam-driven, its engines are simple, non-condensing and it is said to be making money.

Several years ago a large manufacturing company in one of the Central States contracted for 2500 electrical H. P. to be delivered over a long transmission line from a water-driven station at the rate of $50,000 per year, or $20 per H. P. By the terms of the contract the entire $50,000 of annual rental was to be paid without regard to the amount of energy actually used so long as not more than 2500 H. P. were drawn from the line at any one time.

On the basis of 3000 working hours per year, which was, no doubt, exceeded at the factory plant in question, this rate amounts to 0.66 cent per electrical H. P., or 0.88 cent per K. W.-hour, if the whole 2500 H. P. are constantly drawn from the transmission system.

In the same State another large manufacturing plant contracted with an electric transmission company for 1000 H. P. at the flat rate of $22,500 annually, or $22.50 per H. P., without regard to the amount of energy actually used. Of course, no more than 1000 H. P. could be taken from the line at any one time under this contract. Assuming again 3000 hours of factory operation yearly, the rate just named amounts to 0.75 cent per H. P.-hour, or 1 cent per K. W.-hour, provided that the load on the transmission line is kept constantly up to the 1000 H. P. limit.

As a matter of fact, it is usually impracticable to keep a factory load just up to a given figure during an entire day, and the result is that users of power at flat rates cannot constantly draw the entire amount of power for which they contract. Flat rates should, therefore, be somewhat lower than corresponding meter rates. Both of the manufacturing companies last mentioned subsequently contracted for additional power on a meter basis at higher rates than those just named.

One of the lowest rates for metered energy to be found anywhere in a manufacturing plant is that made to a large cotton mill in a city where almost all of the current distributed by the electrical supply system is transmitted from water-powers. In this case the energy is all sold by meter, and the rate is 0.54 cent per K. W.-hour.

Aside from the fact that the energy in this case is derived from water-power, there are two main causes for the unusually low rate. One of these is the large amount of energy consumed in the operation of the mill, and the other is the fact that the contract with the company operating the mill allows the supply of current to be shut off there between the hours of four and six in the afternoon of each day, from the middle of September to the middle of March in each year.

This provision of the contract between the cotton mill and the local electrical supply company enables that company to sell power to the mill during those hours of each day when the lighting load is small, and to cut off the mill load when the lighting load on the supply system is greatest. Much of the energy sold to the mill is thus represented by water that would go to waste over the dams of the water-power plants that feed the distribution system during the hours when little lighting is done.

When the supply of electric current is shut off at 4 P. M., the cotton mill suspends work, and the low rate for power at other times of the day is thought to warrant this practice on the part of the mill. A curve of the power required to operate this cotton mill from morning until 6 P. M. shows a decided falling off of the power between 4 and 6 P. M., resulting obviously from the fact that the operatives are tired and do not work with the same energy during these last two hours as in the earlier parts of the day. This fact is another reason why the

mill can afford to shut down at 4 P. M. during a part of the year.

Nearly thirty motors are employed to drive the machinery in this cotton mill; their respective ratings vary from 3 to 300 H. P. each, and their combined capacity is more than 3400 H. P. One motor of 200 H. P. is synchronous and all the remainder are of the induction type. Current for the larger motors is delivered at about 2300 volts, and for the smaller sizes this voltage is reduced to about 550. A part of the energy sold by the electrical supply company that furnishes current to this cotton mill is developed in a water-power plant belonging to the company, and another part is purchased from a company operating a distant water-power and a transmission system.

Sales of electrical energy between electric transmission systems, electric distribution systems and street railways seem to be made at little, if any, lower rates, quantity considered, than are similar sales to large manufacturing plants.

Several years ago an interurban electric railway, with one terminus at an interior city of New England where the electrical supply company develops its energy partly with steam and partly with water power, found it necessary to contract for a supply of 550-volt direct-current to its line at this terminus. A contract was closed between the railway and the electrical supply company for current at the meter rate of 2 cents per K. W.-hour. The maximum power to be supplied under this contract was not over 250 K. W.

In one of the great cities east of the Mississippi River the street railway system develops a part of the current necessary to operate its cars with steam-power, and purchases the remainder of its required energy from the local electrical supply system. Formerly the electric railway operated entirely with current developed by steam-power, but, after the local electrical supply company began to draw most of its energy from water-power plants, the railway company found that they could purchase a part of their required current cheaper than they could generate it with coal.

In this case the energy is supplied to the station of the railway company in the form of alternating current at about 2300 volts, and is received by motor-generators having a combined rating of 3500 K. W. on the direct-current side. These motor-generators deliver direct current of 500 to 600 volts, and their combined capacity is somewhat less than that required to operate the street railway system at its periods of maximum load.

All of the energy supplied to the motor-generators passes through meters, and the rate for it under the contract is between 0.50 and 0.60 cent per K. W.-hour. This rate makes it worth the while of the railway company to let steam-power apparatus and direct-current dynamos of a capacity equal to that of the motor-generators stand idle.

In 1896, the local electrical supply company in one of the large cities of New England entered into a contract with a company operating an electric water-power plant and transmission line for the entire output of this plant during the next twenty-five years. Under the contract the water-power company was to pay one-half of the cost of labor to operate its generating plant, and the electrical supply company was to pay the other half.

This latter company also provided new electrical equipment to increase the capacity of the water-power station at a cost of about $15,000, and agreed to pay an annual rent of $25,000 for the entire output of the water-power system. Allowing 10 per cent. of $15,000—that is, $1500—for the annual interest and repairs on the new generating equipment purchased by the electrical supply company, and $2500 for the yearly payment to cover one-half of the labor at the water-power plant—about the actual expense—the total yearly sum to be paid for the energy from this plant was about $29,000.

The rental of $25,000 to be paid yearly to the water-power company was subject to a reduction for any failure in operation of the equipment of the water-power plant, but was to be due regardless of the amount of energy actually developed by that plant. The plant has the entire flow of the river on which it is located, but the electrical supply company takes the risk as to the amount of water available.

During the calendar year of 1900, the electric water-power and transmission system delivered 2,777,000 K. W.-hours to the local electrical supply system. If there were no deductions for loss of energy due to failures of equipment in that year, the rate paid for the energy just named was 1.04 cents per K. W.-hour on the basis of $29,000 as the total outlay of the electrical supply company for the service. During the year 1901, the energy delivered to the electrical supply system from the water-power was 2,900,000 K. W.-hours, and the corresponding rate was thus 1 cent per K. W.-hour. The generating capacity of the water-power station in this case is 1800 electrical H. P.

As may be seen from the above cases, a mere tabular statement of rates paid for electrical power in bulk is of only limited value because of the varying conditions of service.

PRICES OF ELECTRICAL ENERGY IN BULK.

Industry Using Energy.	Maximum Power Delivered.	Price per Kilowatt-hour.
Textile mills......	600 H. P.	Less than 4.4 cts.
Textile mills......	800 K. W.-hours per day.	About 1 cent.
Textile mills......	3,400 H. P.	0.54 cent.
Cement plant.....	1,000 H. P.	1 cent.
Machine works...	1 500 H. P.	0.88 cent.
Any industry.....	50 H. P.	2.53 cent.
Electric railway..	3,500 K. W.	0.5 to 0.6 cent.
Electric railway..	250 K. W.	2 cents.
Electrical supply system..........	1,800 H. P.	1 cent

In the table here presented, each case is designated by the kind of industry in which the energy is used and by the maximum power delivered. By this means each case may be traced in the foregoing description and its particular circumstances noted.

Exploiting of Water Power in Germany

ACCORDING to United States Consul Joseph J. Langer, at Solingen, the German Government is planning the exploiting of water power in Germany on a large scale, the intention being to find out what there is in the country as to water power and to what extent it is being utilized. Besides compiling the water-level observations since the year 1896, water volumes are also to be ascertained, and, furthermore, it is intended to collect information as to the power used by manufacturing plants deriving their energy from water power. It is also suggested to find out how much water power is used for each particular industry, as well as for agricultural purposes. This, in turn, would show which branches of trade should receive the first attention in having water supplied to them for power purposes, and the State itself would be placed in a position to aid financially in utilizing the national riches now lying dormant in water power.

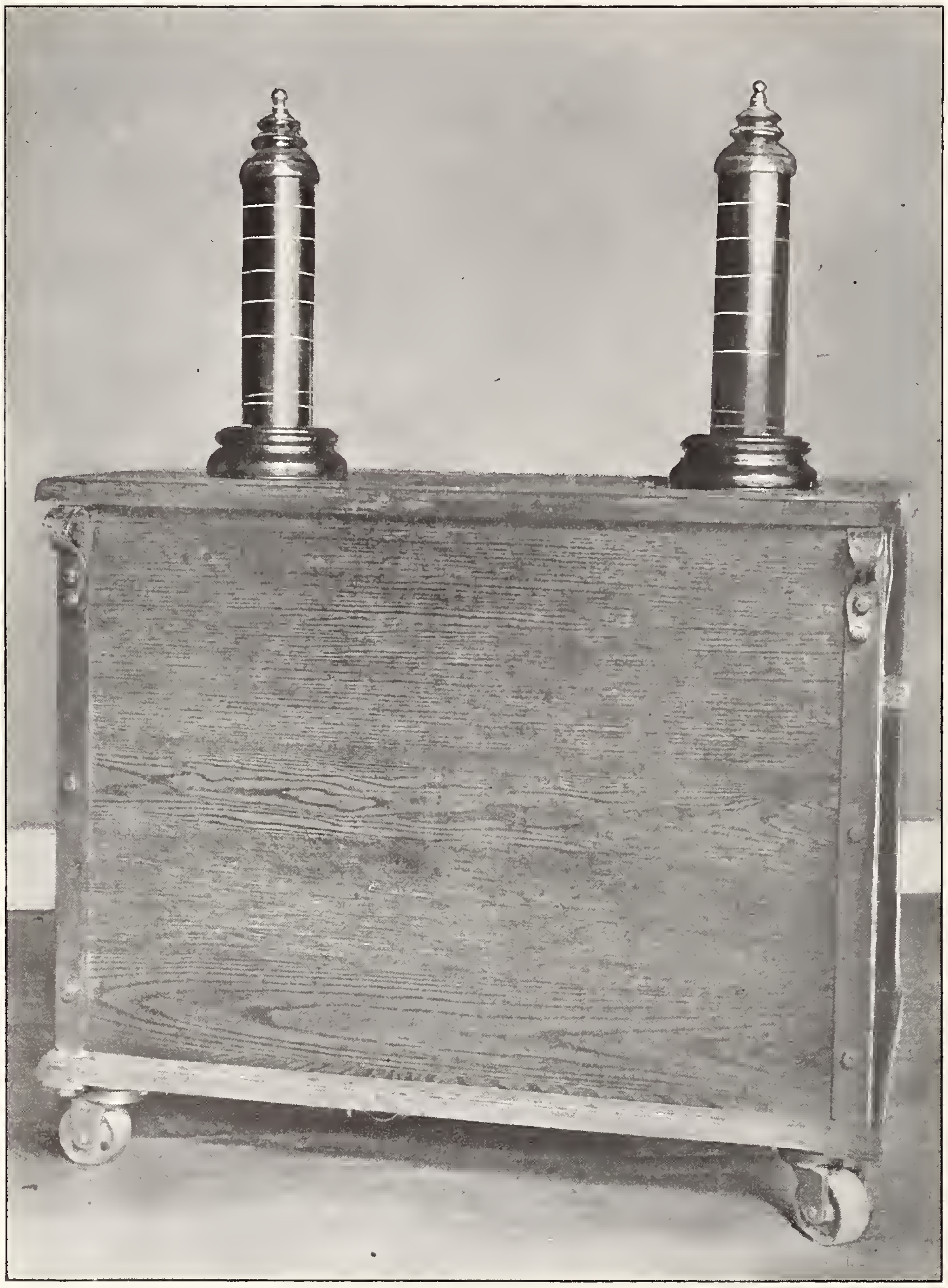
One of the uses to which the lifting power of magnets has been put is that of withdrawing small pieces of iron from the human eye. Quite recently the case was reported of a man who was struck in the eye by a flying piece of steel, which perforated the cornea, iris and lens, and entered the vitreous body which became filled with blood. It was decided to make an attempt to extract the metal by means of a powerful magnet. After bringing the magnet almost into contact with the eye, a piece of steel about 0.156 inch long and 0.136 inch wide was drawn out of the eye and adhered to the magnet.

Notable Electrical Exhibits at the St. Louis Exposition

By CLOYD MARSHALL

SO enduring was the impression made by the Columbian Exposition in the minds of the people that it forms the basis of comparison for other world's fairs. The first natural query regarding St. Louis is of those things which have been discovered and made subsequently to the great Chicago Fair. Since that time wonderful strides have been made in the art and application of electricity. By its agency, light, power and communication have been made available to all. It has brought different peoples in such close communication with one another that on land or sea word can be sent to or received from far-distant parts of the world. Not only has the work in this line resulted in many discoveries, but the adaptation of science to industrial problems and the development of machinery have also gone on at an accelerated pace. The commercial expansion also has been so rapid that the electrical industries to-day represent one-twentieth of the wealth of the entire nation.

Electricity has contributed much to the grandeur and success of the Louisiana Purchase Exposition. For lighting, transportation and the transmission of power it has superseded all other agencies. The special exhibits showing the great progress since the Columbian Exposition are chiefly in the Palace of Electricity, where they are classified under five groups:—Machines for generating and for using electricity; electro-chemistry; electric lighting; telegraphy and telephony; and the various applications of electricity.



A 500,000-VOLT TRANSFORMER EXHIBITED BY C. H. THORARDSON, CHICAGO, ILL.

The large generators direct-connected to engines are placed in the Palace of Machinery in order to be near the boiler house. Among the prime movers, a turbine alternator unit, exhibited by the General Electric Company, of Schenectady, N. Y., represents a recent development. This unit is of 3000 H. P. capacity, and consists of a Curtis turbine direct-connected to an alternating-current generator. The condenser for the turbine is in the base of the machine, and thus the entire outfit occupies the smallest possible amount of floor space, or not more than is ordinarily required for a generator.

In power station equipment the exhibits consist of very comprehensive lines of switchboards, with instruments and switches of types which are practically all of recent development. This is especially true of the oil-break switches, which will safely rupture a circuit of as high potential as 60,000 volts.

The distribution of power over long distances is one of the most important fields of usefulness for electricity. To do this economically very high potential currents are necessary. While ten years ago 10,000 volts were considered excessive, to-day lines of 50,000 volts potential are in regular service. C. H. Thorardson has in operation a transformer which raises the potential from 120 to half a million volts, with a regulator in the primary circuit which gives a secondary potential from zero to 504,000 volts. A series of alternating-current induction experiments are being made with 60 and 120-cycle current. The transformer has a maximum capacity

ONE OF THE GENERAL ELECTRIC COMPANY'S EXHIBITS

of 20 K. W., and primarily is intended for testing and laboratory purposes.

The successful production of the single-phase, alternating-current railway motor constitutes one of the most important electrical developments of the past two years, and it is unlikely that any other single technical exhibit at the Fair will be viewed with so live an interest. The possibilities for the application of electricity to broader fields of railway service opened up by this achievement are not easily realized to their full extent. The Westinghouse exhibit contains two such motors mounted and in operation on a truck, with induction regulators, a large auto-transformer, air-operated switches, a master controller and the usual air brake equipment.

The single-phase railway motor is the result of the desire and the tendency to do away with rotary converters as an intermediate link between the power house and the car. The principal advantage of this system is the better transmission of energy at both high and low tension and not the inherent superiority of the alternating-current motor over the direct-current motor. The new system, as illustrated in the Westinghouse exhibit, is not revolutionary, but simply an improvement over the old order of things; thus, with an existing direct-current system it is possible to use the same generators and the same line and transformers, changing only the equipment of the cars. Moreover, cars equipped with alternating-current motors can run over old districts in which the cars are operated with direct-current motors.

The mercury arc rectifier is one of the latest inventions in electrical science, and one is exhibited in operation. In the space of the General Electric Company is one receiving alternating current, which is converted without the use of any mechanism into direct-current, driving a $7\frac{1}{2}$-H. P. motor.

One of the features of the lighting exhibits at the Fair is the display of Cooper Hewitt mercury-vapor lamps in the Palace of Electricity. About two dozen tubes are used for the illumination of the Westinghouse exhibit service plant and for a special demonstration in the Westinghouse auditorium. Over the auditorium itself is a mercury-vapor tube 8 feet long, and in the Palace of Electricity in the Westinghouse exhibit is a tube of similar size. The Cooper Hewitt lamp, which has been declared to be the one material advance in photography in the past generation, is used by the Official Photographic Company for portrait work in its booths on the plaza, by the Official Pass photographers for all pass portraits taken on the grounds and in the postal photo booths in the Tyrolean Alps. In the Westinghouse auditorium three exhibitions are given daily of an interesting series of biograph and mutoscope pictures of scenes in and around the Westinghouse works in the Pittsburg district, in which are included the first interior moving pictures ever taken. These pictures were obtained by means of the Cooper Hewitt lamp, and are the most striking demonstrations that have yet been made of the lamp's actinic efficiency. By its use it was possible to take pictures at a speed of 900 a minute, or 15 a second, in the blackest forge rooms and foundries.

It is claimed for the mercury-vapor lamp that actual tests have shown it to

be less fatiguing to the eyes than any other artificial light, that it is the most economical light of the present day, and that its absolutely even illumination makes it particularly pleasing to draughtsmen, machinists and stenographers, and in fact in all places where the question of color does not come into consideration. The ordinary enclosed-arc lamp takes more than twice the current consumed by the mercury-vapor lamp, while the old open-arc lamp requires almost ten times as much current. The Cooper Hewitt lamp is simple in construction, with no mechanism to get out of order and no carbons to trim or replace. The lamps are shown as designed for use in general illumination, photography and photo-engraving, and with sample printing outfits for photographers. In many of the Pike shows the lamps are used for illumination in places where their peculiar greenish light will afford entertainment and amusement.

A WIRELESS TELEPHONE RECEIVER

The General Electric Company also exhibit mercury-vapor arc lamps, which are shown for the first time in any exposition; a new luminous arc lamp is also shown, using magnetite instead of carbon. This lamp has a very marked increase in efficiency over the carbon burning lamps, and is especially suitable for street lighting.

It is also worthy of note that the entire system of arc lighting used by the exposition has been developed since the World's Fair at Chicago. This is known as the series, alternating, street-lighting system, using enclosed-arc lamps for lighting the interior of the buildings, the outlying parts of the grounds and the Pike. The General Electric Company also exhibit enclosed-arc lamps for all kinds of commercial electric circuits, and these have a life of 100 or more hours.

It is interesting to recall that the first public exhibition of Nernst lamps in any considerable number was at the Pan-American Exposition in 1901, yet to-day the new lamp is playing an important part in the lighting of the exposition. The most important installation of Nernst lamps at the Fair is in the Fine Arts Building, where over 6000 are used. For this purpose the pure white light of the Nernst lamp has effectively solved the problem of artistic ilumination. The Westinghouse exhibits in the Palace of Electricity, of Machinery and of Transportation are all brilliantly lighted by the Nernst lamp, and special demonstrations of the light's strength are given daily in the Westinghouse auditorium by comparison with incandescent globes. The handsome Illinois State Building is lighted by Nernst lamps, and the National Cash Register Company uses them in its various exhibits.

The peculiar advantages claimed for the Nernst lamps may be summarized briefly as high efficiency, beautiful quality of light, perfect distribution of light, absence of shadows of the light iself, the steadiness of the light and the fact that the glassware is removable for cleaning, as there is no vacuum. It is but slightly affected in candle-power by variations in the line voltage and is free from noticeable pulsations, even on alternating circuits of low frequency. Because of its brilliancy and economy the Nernst lamp will cause a demand for more light rather than an entire supplanting of any other form of illumination.

The exhibit of the United States Incandescent Lamp Company, to be seen in the Palace of Electricity, is one of the most valuable educational exhibits in the building. In the space occupied by this company the visitor can see the various steps and processes in the manufacture of an incandescent lamp, and these are carried on in such a manner that, starting with the squirting of the filament, one can see, by walking entirely around the exhibit, each step in the proper order. The filament, which is the light emitting portion of the lamp, consists of cellulose, a combination of cotton, wool and nitric

acid, which is forced through a glass die to make a slender thread resembling ordinary catgut in color and texture.

After being dried and cut into lengths, the filament is wound on carbon forms to give it the proper shape, these forms then being packed in carbon and subjected to a temperature of about 400 degrees. In this process the cellulose is entirely carbonized. In the next treatment, called flashing, the carbon is raised to a high temperature by means of an electric current passing through it, being surrounded the while with hydrocarbon gas. The high temperature to which the filament is raised decomposes the gas, and a thin skin of graphitic carbon is deposited upon the filament, which is then ready to be attached to the glass stem.

The glass tube supporting the carbon is made from short lengths of lead glass, which are flanged at one end and closed at the other, two short lengths of platinum wire being sealed in at this second operation. Welded to the outside end of the platinum are short lengths of copper wire, which are soldered to the brass base of the lamp and through which the current is carried to the filament. Platinum is used to connect the copper leading-in wires to the filament because of the fact that platinum has practically the same coefficient of expansion as glass, and it is used where the connections pass through the sealed end of the stem. If copper were used the glass would soon crack, owing to the unequal expansion of the copper and glass.

The stems are now ready for the filaments, and the latter are attached to the platinum with a paste composed of sugar and graphite. After being baked to remove moisture in the joints, the stems with filaments are inspected, straightened and adjusted. The bulbs are blown in moulds from a high grade of lead glass and are without the usual tip that appears on the end of an incandescent lamp. At the small end of the bulb the neck is 3 or 4 inches long, and the first operation is to remove all but about half an inch of this in the flame of the glass-blower's fire. A small piece of glass tubing is then sealed into the large end of the bulb and drawn out so that but a small opening remains; this serves later as a vent through which the air is exhausted from the bulb.

When the bulbs are fitted with tubes and cut off, they are ready for the sealing in of the stem and attached filament. This is done in a simple machine, which holds the bulb in a chuck and revolves the neck in the glass-blower's flame, the filament being inserted and held in position by a pair of clips atached to a vise; the whole is revolved and the stem and bulb rapidly fuse and weld together. A small amount of chemical is then inserted in the tube to assist in producing a vacuum therein.

After the preliminary exhausting, which removes the moisture, the lamps are taken to the exhausting table, where they are attached by means of a rubber coupling to the air pump. The filaments are connected to a source of current and raised to a high incandescence. Under the action of this heat the chemical introduced into the bulb combines with the oxygen and materially assists in producing the degree of vacuum required. When this stage is reached a small blow-pipe is directed against the tube and it is sealed, thus closing the bulb and leaving a small tip on the end of the latter.

The lamps are then subjected to a glow test in which the one wire is touched against the terminal of an induction coil, the resulting glow in the bulb indicating the degree of vacuum. A small brass base is then fixed to the bulb by means of a waterproof cement, and the wires leading to the filament are soldered to this to form connection. The lamp is then ready for final inspection and packing. About twenty minutes are required to see the entire series of operations, and some idea of the size of the installation can be obtained from the fact that over 1500 standard 16-candle-power, 110-volt lamps can be made each day.

Wonderful advancement has been made in wireless telegraphy since the first demonstrations were made about eight years ago, and the visitor will be impressed with the exhibits in this line. The De Forest Wireless Telegraphy Company have extensive exhibits in the Electricity and Government Buildings—a 300-foot tower and a 250-foot mast for sending commercial messages to Springfield and Chicago. Exhibits are also made by Marconi and Ducretet.

Telephones are freely distributed throughout the buildings and grounds for the use of both exhibitors and the public, and, by means of the connection through the St. Louis exchanges, one can converse from one exhibit to another, to any building on the Fair Grounds, to any place in the city, or as far east as the Atlantic and west to the Rocky Mountains. Telegrams, cablegrams, and even aerograms, can be sent from the telegraph stations within the building to any part of the world. Although these facilities are in universal use, yet but few understand the operations necessary to give such service, so that the operating companies have demonstrations to explain the workings of the apparatus and systems.

The American Telephone and Telegraph Company have installed in the Electricity Building a complete equipment for a standard Bell exchange in active operation. Service is furnished to all subscribers on the Exposition Grounds, and connection is made to all exchanges in the United States reached by long-distance lines. The switchboard has an ultimate capacity of 9600 lines, 9600 multiple jacks and

NERNST AND COOPER HEWITT LAMP EXHIBITS

A RADIOPHONE RECEIVING STATION AT THE ST. LOUIS EXPOSITION

600 trunks, but the Exposition service requires 1500 lines, which are brought to the exchange through an extensive underground plant.

The Kellogg Switchboard and Supply Company have in their exhibit a board, of an ultimate capacity of 3600 lines equipped with 1200 lines. The system extends throughout the entire Exposition Grounds and buildings, and is connected with the Kinloch Telephone Company, thus giving service to the city of St. Louis and all long-distance independent lines.

The Automatic Electric Company combines with its exhibit a service throughout the Electricity Building. At convenient locations in the building and throughout the offices of the department are located automatic telephones. The exhibit includes two complete working automatic exchanges of the 10,000 type, each with 100 stations installed. These two exchanges, now giving service throughout the Electricity Building, are connected together by a system of trunks similar to that generally used in manual telephone practice to connect branch exchanges with each other and with the main exchange.

The selection of trunks, however, is done automatically and not through human agency, as is the case in manually-operated switchboards where a call originating in one exchange must pass through the hands of two operators to secure connection with a telephone in another—a method which, since the number asked for must be repeated by the original to the secondary operator, of necessity consumes considerable time. This method has added disadvantages, in that it offers double opportunity for errors to occur, and requires that the subscriber's memory be burdened by the use of names prefixed to the numbers to designate various exchanges. The automatic system requires the use of no name prefixes, and the subscriber need not be aware that he is calling through more than one exchange, since the directory contains only numerical designations. In all cases three or four rotations of the calling dial will secure instantaneous communication with the telephone desired.

A demonstration of the wireless telephone is made by M. R. Hutchison. Around the court of the Electricity Building there is a circuit of wires connected to the booth in Block 21. Before a water-cooled transmitter in the booth music is played. In the court no sound of this is heard until a pocket telephone receiver, without any external wire connection, is placed to the ear, and then the music becomes audible. At any point in the court music can be heard by the aid of the receiver.

The exhibit of a radiophone transmitting and receiving station, made jointly by the American Telephone & Telegraph Company and the General Electric Company, is proving one of the most attractive exhibits in the Palace of Electricity. The radiophone is a combination of an arc light, reflectors and what is known as a selenium cell, and by this means speech is transmitted to distant points without the use of wires or other such intervening medium, the translation taking place by means of a beam of light furnished by the arc and projected in a slender beam by a parabolic reflector.*

In the Palace of Electricity, on an elevated platform under the office gallery, is located a sound-proof telephone booth, in which is installed an ordinary telephone transmitter. Just outside of the booth is a 16-inch projector, connected with the transmitter in such a way that the movement of the diaphragm in the latter, occasioned by sound in its vicinity, causes the volume of current passing through the arc to vary. This causes a corresponding variation in the intensity of the light emitted; but these changes in the beam of light are too rapid and too slight to be noticed by the eye. The receiving station consists of a 30-inch reflector, at the focus of which is placed a selenium cell. This consists of a small cone, about half an inch long, made of pipestone. In the spiral thread cut in the cone are wound two fine brass wires a small distance apart. Selenium is then pasted over these wires in a thin coat. This element possesses the property of rapidly changing its electrical resistance under variations of light. If the resistance of a certain piece of selenium be measured in the dark it will be found to be many times greater than if measured in the light. As these changes take place instantaneously, it follows that the selenium cell placed at the focus of the receiving reflector will rapidly vary in resistance in accordance with the fluctuations taking place in the beam of the search light. If the selenium cell be connected with a telephone receiver and battery, the sounds produced in front of the transmitter will be faithfully reproduced in the receiver. The entire installation is exceedingly simple and is well worth a visit to this building.

The Hutchison Acoustic Company give demonstrations each day of the "acousticon" and "massicon,"—electromagnetic instruments for overcoming deafness. Deaf mutes are brought to the exhibit and are made to hear music and the voice by using the acousticon. This apparatus consists of a small battery, a specially designed telephone receiver and a transmitter which amplifies the sound and imparts the waves to the auditory nerves. The massicon is a magnetic instrument which emits sound waves in sharp, saw-tooth form, setting the eardrum and ossicles in vibration and stimulating them, thus restoring the ear to its normal condition—a process similar to the massaging of weak muscles.

In the court of the Electricity Building the Electra Water Purifier Company is exhibiting the Kune process of purifying water by electricity for commercial purposes. The electric purifier has a capacity of 500 gallons of purified water per hour, the current being 15 amperes at 15 volts. The apparatus consists of a purifier, generator, switchboard, a precipitating plant and a filter. The electric current destroys the bacteria and organic matter, also reduces the salts of lime, sodium, magnesium and the like, and any soluble salts of metallic compounds are eliminated. The electrolytic action produces an insoluble hydrate, which coagulates the released impurities in an insoluble mass and precipitates them, so that when the water has passed through the strainer or filter, it is free from the impurities. Another interesting feature is a collection of samples of water from the principal cities of the United States before and after being subjected to this treatment.

The exhibits of electro-therapeutic apparatus are proving to be very popular on account of X-ray demonstrations and high-potential discharges. Static machines, resonators, current rectifiers and Finsen lights are included, and all are demonstrated at regular intervals in the Electricity Building.

There is no branch or phase of the electrical industry which has not made substantial advances during the past decade, and they will be fully appreciated, especially by the electrical engineer, after a careful examination of the extensive and diversified electrical exhibits at St. Louis, all of them in operation or demonstrating service conditions.

* It may be of interest here to refer to the additional particulars of the radiophone given in the article by Mr. F. G. Fassett on this page.

The Latest Form of Radiophone

BY F. G. FASSETT

NEARLY twenty-five years ago Alexander Graham Bell demonstrated that any one of a great variety of substances will emit sound when a beam of light of rapidly

varying intensity is thrown upon it. Dr. Bell also showed that the element selenium can be made to produce sound under the action of light, the sound in this case being due to the changing resistance of the selenium to the passage of an electric current.

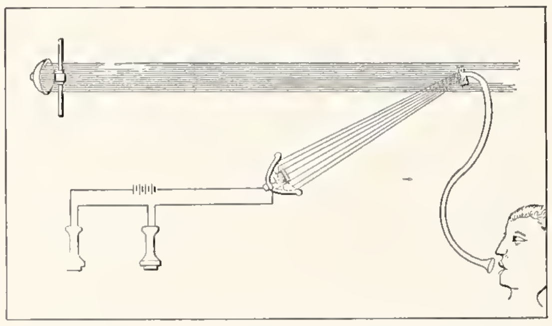
Dr. Bell and Mr. Charles Sumner Taintor, who was associated with him in the experiments, devised the apparatus to which the name of radiophone was given, and by means of which selenium and other substances were made to reproduce the tones of the human voice and the words spoken at the transmitting apparatus. The investigators proceeded on the theory that if the fluctuations in the beam of light were made to correspond with the sound waves set in motion by the voice, then the reproduced sound would be a repetition of the spoken words. Mr. Bell, in his first apparatus, threw a beam of sunlight upon a very thin mirror by which the light was deflected to a reflector in which was placed a glass bulb containing the selenium or other substance employed. Attached to the back of the mirror was a mouthpiece and when words were spoken into this the glass vibrated in unison with the sound waves.

When selenium was used in the receiving apparatus, a tiny bar of the metal was brought in contact with the wires, forming an electric circuit which included a telephone receiver. As the selenium responded to the alterations in the intensity of the light, there were corresponding fluctuations in the telephone current and these reproduced in the receiver the sounds which caused the mirror and the light rays at the transmitting end of the apparatus to vibrate.

Dr. Bell's experiments demonstrated that the selenium receiver would produce sound, but in practice it was found that it did not give satisfactory results. Then a type of receiver was developed in which the selenium and the telephone circuit were eliminated. In this receiver a bit of lamp black or blackened vegetable fibre was placed in a glass bulb, from which extended rubber tubes ending in ear pieces of the kind since made familiar by the graphophone. As the beam of light varied in its intensity, the substance in the bulb alternately expelled and absorbed gases. These, in turn, acted upon the columns of air in the tubes, setting up vibrations. These reproduced the sounds which caused the light ray to fluctuate.

This form of receiver has been superseded by the improved type in which selenium is again employed, but it is worth remembering, as it recalls the fact that the down blown from the thistle in the field, the frayed fragments of a woman's black silk gown, the bit of lamp black hardly large enough to soil the fingers, or any other of a great number of substances may be made to talk.

With Dr. Bell's apparatus, in the later forms of which electric light took the place of sunlight, it was possible to hear with reasonable distinctness over a distance of 600 or 700 feet. The Bell radiophone was exhibited at the Columbian Exposition in Chicago and attracted a great deal of attention. To-day there is on exhibition as a part of the display of the Bell telephone system at the St. Louis Fair an improved radiophone which is capable of transmitting sound over the rays of an electric search light for distances measured by miles instead of feet.



AN OUTLINE SKETCH OF PROFESSOR BELL'S RADIOPHONE CIRCUIT

This perfected radiophone is the result of work done by Mr. Hammond V. Hayes, an engineer of the American Telephone and Telegraph Company, who began his experiments and researches in 1896. In the year following, while an electric arc light was being used in the experimental work, an assistant of Mr. Hayes noticed that a humming sound was audible, which corresponded to that made by the generator supplying the lighting current. It was also found that the radiophone receiver was so sensitive that it reproduced this humming sound.

The discovery suggested the possibility of superposing a telephone current upon the lighting current, and when this was tried by placing a telephone transmitter in a short circuit about the lamp, it was found that words spoken into the transmitter caused fluctuations in the lighting current and corresponding vibrations in the beam of light. Thanks to Mr. Hayes' investigations, the old-time transmitter, consisting of the mirror and mouthpiece, has been discarded, and in its place a delicate telephone transmitter is used. Furthermore, the result of superposing one current upon the other is to greatly increase the effect of the telephone current, and consequently to increase the distance over which the radiophone may be successfully used.

The radiophone of to-day consists of an electric search light with which are connected the wires of the telephone circuit in which the transmitter is placed. When words are spoken into this transmiter there are variations in the lighting current and corresponding fluctuations in the intensity of the light. The light flashing over a distance, perhaps measured by miles, falls against a parabolic reflector which concentrates it upon a bit of selenium enclosed in a tiny glass bulb. The selenium is spread in a thin layer over two brass wires wound around a bit of Indian pipe-stone. How delicate is the workmanship in this little contrivance is realized when it is stated that each convolution of the wire is separate from the next by a distance of about one sixty-fourth of an inch. The selenium cell is included in an electric circuit, with a telephone receiver, and, as the light falls upon the selenium, words spoken at the transmitter are reproduced in the manner already described.

There are other remarkable features connected with the radiophone. During the experiments which led to its perfection, it was discovered that an arc light is a very fair telephone receiver. In other words, the arc itself can be made to talk when a telephone current is superposed upon the lighting current and one of the interesting features of the experiments conducted by Mr. Hayes was the reproduction of bugle calls by means of the arc light instead of the ordinary radiophone receiving apparatus. The point where the bugle was played was so far from the lamp that no sound of the notes could be heard, except as they came clear and distinct from the lamp itself. The explanation of the manner in which an arc light becomes a telephone receiver is so simple that even the layman may understand it. As the carbons in the lamp are consumed, they are surrounded by a column of vapor. When the lighting current is fluctuating under the influence of the telephone current, the fluctuations set up in this column vapor vibrations, which, in turn, send sound waves out through the air, and these falling upon the ears of the listener reproduce the transmitter.

The radiophone has as yet been put to no commercial use, and what its future will be is not known, but it is of exceptional interest as showing the possibilities of telephony and as also revealing the wonderful properties of some of the everyday objects with which we are surrounded.

About 10,000 Nernst lamps are in use in the several St. Louis Exposition buildings.

Notes on European Electrical Practice

By CLAYTON H. SHARP, Ph.D.

ALTHOUGH the great body of American electrical engineers are quite familiar with the broad features of the development of electrical science in foreign lands, yet it may be of interest to review this development and to learn how certain peculiarities of European practice appeal to an American observer. The notes here presented do not pretend to any degree of novelty or of depth, being the result of casual observations made outside the lines of the writer's particular mission in Europe. The time during which these observations were made extended through the months of October, November and December, 1903. The trip was made in the interests of the Electrical Testing Laboratories, of New York, with a view to perfecting their equipment and practice.

At the present time, when the New York public is looking forward with a good deal of expectancy to the opening of the Rapid Transit Subway, a few notes on the subways of European capitals may be of interest. Perhaps the most famous of these is the Central London Railway, the "Twopenny Tube." This road, running in deep tunnels, is equipped after American models and gives what seems to be a satisfactory science. The speed of the trains is, however, rather slow, and the ventilation of the tunnels, which is provided for only by the shafts at the stations, is bad. In warm weather the air in them is agreeably cool, but in cold weather its foulness and staleness are very noticeable.

The cars are quite similar in arrangement and general appearance to those of the New York elevated. However, they fit the tubes so closely that one is tempted to speculate on what would happen in case of a serious accident, such as a derailment occurring between stations. Egress from the cars, except by the end of the train, would quite probably be cut off, and the results of a panic might be most disastrous. The Waterloo & City Railway, running trains between Waterloo station and Bank, is not nearly so well equipped as the "Tube," and its trains are very noisy. The old underground, the Metropolitan, with its shallow tunnels and open cuts, should make, when equipped with electrical traction, a far more agreeable road to ride on than either of the foregoing.

The Metropolitan, of Paris, is a subway but little beneath the surface. While the entrance and stations are fairly commodious, the rolling stock impresses one as being poor. The cars are light affairs on four wheels and by their flimsy construction and imflammable material seem almost to invite such a catastrophe as occurred last summer. There is a great deal of noise in this subway, and the motion of the cars is far from smooth.

The Berlin Elevated & Underground Road exemplifies a much higher class of construction. The cross ties of both the elevated and the underground portions of the road are laid in ballast. The cars move smoothly and with little noise. On both the Paris and the Berlin underground roads the cars are entered from the side, but the customary division into compartments has not been adopted except so far as is necessary to separate the second and third classes and the smoking from the non-smoking. The arrangement seems to be a very advantageous one as far as quick filling and emptying of the cars is concerned.

It is safe to say that none of the above-mentioned underground roads is, in point of construction, equipment or operation the equal of what we are reasonably expecting in the New York subway. Considering the fact that our New York engineers have been able to profit by the experience and the mistakes of their foreign confrères, and have by no means been seriously hampered by lack of funds, it would be discreditable to them if this were not the case.

In the matter of metering electricity, foreign practice does not seem to be as advanced as American. It is true that before a new type of meter can be introduced into public service in England, it must have the formal approval of the Board of Trade. The laboratory of the Board of Trade, under the direction of Mr. Trotter, is largely given over to systematic tests of meters awaiting approval. Before an approval becomes final, the meter must successfuly undergo an endurance test extending, perhaps, over a year's time. But the meters which the supply companies find available do not seem to be as good as in this country. In appearance, at least, foreign meters are inferior to American. The standards of accuracy are not placed so high as in the best American practice.

In London, meters are liable to be rechecked on demand, under the authority of the London County Council, which maintains a laboratory for that purpose. English practice is more diversified in respect to the types of meters used, running to a considerable extent to ampere-hour meters, and employing a considerable number of electrolytic meters and Aron meters. Prepayment meters are quite largely used, and double-tariff meters meet with considerable favor on the Continent. In a number of German cities official testing laboratories for the verification of meters are maintained under the general supervision of the Reicsanstalt. The laboratory of this kind at Munich is a particularly noteworthy instance. It is housed in a commodious and ornate stone building, and is equipped in a most excellent manner. The wide limits of allowable variation from absolute accuracy permitted under German regulations make such elaborate provisions for the verification of meters seem almost ridiculous, since sufficiently accurate tests could be made with comparatively crude facilities.

In that application of electricity which most naturaly attracts the attention—electric lighting—there are well-marked differences to be observed. As a general thing, electric lighting is not so well carried out in London as it is in Paris, Berlin and New York. The general tendency in that city in lighting with incandescent lamps seems to be to obtain long life at the expense of high efficiency or to use cheap lamps at the sacrifice of both of these qualities. The London public seems to be quite uneducated as to the relative positions in the expense account occupied by lamps and by electrical energy; so that, in spite of the lower prices of lamps which there obtain, K.W.-hours are recklessly consumed in lamps which hold fast to life with the proverbial British pertinancity, while emitting a glow

which is but a mockery of the electric light. The more enlightened American policy of renewing dim lamps free of charge is unknown to the electricity supply companies of London, who take the stand that it is electrical energy which they are selling, not light.

It must be said that the most progressive electrical engineers in London recognize and deplore the state of affairs brought about by the haphazard renewal of lamps by the individuals using them. The obstacles in the way of any change in the system are serious. Among these is the opposition of the supply dealers and the ironmongers, who do not wish to lose their retail business in lamps. The charters of some of the electricity supply companies expressly forbid the companies to recommend any particular make of lamps, and so, constructively, prevent them from furnishing to their customers any particular make to the exclusion of others. It facilitates the successful adoption of a system of free lamp renewals if the lamps are bought at such prices as can be comanded only by placing large orders; hence, under this system, orders are usually concentrated and are placed with only a few lamp makers. It is apparently impossible to do this under the charter restrictions cited. This concentration of orders is desirable for still another reason, namely, to obtain lamps which shall be moderately uniform in quality. Uniformity in quality is a requisite quite apart from excellence, since the performance of uniform lamps can be reckoned with and the desired result in the shape of uniformity in illuminating effects can be obtained.

Moreover, the English lamp buyer is handicapped by the fact that there is nowhere in England a laboratory such as exists in this country for carrying out on a large scale commercial tests of lamps to determine their quality and their fulfillment of contract specifications.

Throughout Great Britain, 100 volts, 110 volts, 200 volts and 220 volts are quite generally adopted as lighting voltages. A standardizing commission has recently recommended 110 volts and 220 volts as the standard tensions for lighting circuits. This practice, by creating an undue demand for lamps of these voltages, militates against their accurate rating, since all lamps turned out measurably near to the 110-volt or 220-volt standard are indiscriminately rated at exactly these voltages. This results in a less uniform grade of illumination, and consequently a less satisfactory one. In this country, where the largest companies commonly adopt odd voltages and shun 110, the results are much better. This is a most inexpensive reform as well as a most satisfactory one.

Two other causes tend to depress the general level of electric lighting in London. One is the extensive use of high-voltage systems. In order to effect economies in distribution and to increase the capacity of existing mains and feeders, the pressures on the three-wire networks of a good many English companies have been doubled. This has rendered necessary the use of high-voltage lamps, running from 200 to 260 volts. Since high-voltage lamps are necessarily made with untreated filaments, they must be operated at lower efficiencies than low-voltage lamps, if the same relative life is to be obtained. The reddish hue of the light from these low-temperature filament gives the illumination a less pleasing effect even though the actual intensity of illuminations is the same.

In this country the standard incandescent lamp is the 16 candle-power lamp. Vastly more lamps af this candle-power are in use than of any other candle-power. In London the standard may be said to be the 8 candle-power unit. Relatively speaking, a great many more 8 candle-power lamps are used than in this country. The result is naturally a diminished average illumination.

In contrast to this extensive use of 8 candle-power lamps is the London practice of using very large incandescent lamps for the illumination of shop windows. A row of these lamps is placed outside the window near the top, each lamp being shielded on three sides by a metallic reflector. Each of these lamps gives a considerable flux of light, at the expense, however, of as much energy as would suffice to operate a small arc lamp.

In both Paris and Berlin, electric lighting in general is carried out better and on a more liberal scale than in London. Berlin in particular is resplendent with light. Not only is the incandescent lamp better handled, but arcs are more profusely used and the newer forms of illuminants are much in evidence. The use of many low-current, open-arc lamps of compact construction and comparatively small candle-power is quite characteristic. These are employed chiefly in the illumination of show windows, either from the interior or the exterior. Three or four or even more such lamps may be seen furnishing light to a single window. The result is that not only is the window splendidly illuminated, but the general brilliancy of the street illumination is also greatly enhanced. The enclosed-arc lamp is not often seen. The flaming arc is also extensively employed for display purposes. These are such very powerful illuminants that their whitish or golden yellow light constitutes a large element of the total luminous flux in the principal business streets. This type of lamp does not seem to have come into prominence as a factor in other than display or advertising illumination, although some of the squares of Hamburg are lighted by this means. Seen on a foggy night their light seems to be particularly penetrating and efficient. The same cause which has caused the open-arc lamp to be displaced to such a large extent in this country by the enclosed-arc lamp, the rapid consumption of its pencils, must operate even more strongly against the extensive introduction here of this novel and effective form of illuminant as it now exists in Germany.

The Nernst lamp is also making considerable headway, thousands of them being in use. The Allegemeine Elektricitäts Gesellschaft, of Berlin, the makers of this lamp, have recently brought out a Nernst lamp with horizontal glower and preheater coils arranged above the glower, all as in the American type of this lamp.

The Auer osmium lamps are also seen to some extent, though chiefly for display purposes, to which they are adapted on account of the whiteness of their light. There seems to be little doubt of the high efficiency and good durability of these lamps, but they suffer from the disadvantage that, on account of their low voltage (50 volts and under), they must be operated two, three or four in series on 110-volt mains, that they must be burned in a pendant position, and that they are very easily damaged in transportation. The price of these lamps is relatively high—5 marks each for the ordinary sizes, with a rebate on returning the burnt-out lamp.

The general impression which one gains on a tour of the principal European cities is that while for many of the novelties in electrical science and art we must go to Europe, yet in point of excellence and extent of the utilization of tried and approved appliances, this country is at the front. If our excellent practice of standardization is not carried to such a degree as to make us follow with too great conservatism the well-trodden paths, there is no apparent reason why this country's superiority in these respects should not be maintained.

It is reported that a large electric central station will be erected by the breweries at Pilsen, Bohemia.

The Importance of Testing

By WILSON S. HOWELL, Manager of the New York Electrical Testing Laboratories

A paper read at the recent annual meeting of the New York Electrical Society

"ETERNAL vigilance is the price of safety." In order to produce the best goods in your line, it is very necessary to know that the quality is up to standard every time and all the time. To know this, continuous or frequent testing is necessary. Many of the most successful producers of electrical goods maintain laboratories equipped more or less completely for the special testing of the goods made by themselves and their competitors. The extensive testing departments of the two large electrical manufacturers are well known, and there is little doubt that their policy of extensive systematic testing has added much to their success, not only by raising the standard of their goods, but also to a great extent by inspiring the purchaser with confidence.

A well-equipped laboratory, with competent men to operate it, entails considerable expense, so that even the larger manufacturers often find it an advantage to have some of their tests made outside, even if only as a check on their own laboratory or to supplement their facilities by having their instruments checked periodically against primarily standards which they do not possess. It is also of great value to a manufacturer to be able to present authoritative and reliable information concerning the quality of his goods, this information being more convincing to a prospective purchaser if made by a disinterested third party.

It is quite safe to claim that the manufacturer who maintains the quality of his product at the top notch of excellence pays liberally for testing. He tests continuously to detect the first evidences of deterioration of quality and carefully watches every process by a system of inspection and tests to insure excellence in the finished product. I know of one manufacturer who claims that he spends one-tenth of his total labor cost on inspections and tests, the results of which are that his product has an exceptionally high value and his sales exceed the output of any three of his competitors. This manufacturer not only spends considerable money on tests in his own laboratory, but he pays liberally for outside tests. He also, to keep informed of the value of the goods made by his competitors, frequently tests their produce as well, and when competing goods are found, having points which rival or excel his, every effort is made to improve his quality and keep the lead.

Few will question the wisdom of the manufacturer in spending money for tests if he determines to build his trade on the firm foundation of quality and hopes to excel in his line; but the cost of equipping and maintaining a laboratory is an expense which in many cases is not warranted, and the manufacturer either has his testing done by others or neglects testing entirely.

Not only the materials of which the machines are constructed, but the completed apparatus also should be thoroughly tested. Poor design, faulty construction or bad workmanship may produce poor machines, even though the selection of materials has been wisely made. It is not safe to rely upon the continued carelessness of the average purchaser of electrical apparatus; he, too, is being educated in the importance of testing, and now inquires intelligently into questions of efficiency, life and the like, and is beginning to demand unbiased proof on these points.

To the latter class I would especially appeal to test everything. If you are a manufacturer of dynamos, motors or transformers, you should purchase only the best materials for the purpose; your iron, copper and insulation should be carefully tested before it is paid for, or especially before it is put into a machine. "The best is none too good" for you, and the cost is not often more than that of an inferior article, while the efficiency and life of your machine is increased out of all proportion to the extra cost involved.

Take the case of the incandescent lamp manufacturers. Do they all know their product accurately? Cannot many of them improve their quality with slight cost by determining their weak points and studying how to improve them? The making of a high-grade lamp requires great skill, and success depends upon testing to a greater degree than some will admit, for it requires a considerable outfit to make thorough and accurate lamp tests, and only the larger manufacturers can afford the equipment and skill necessary. Every manufacturer should know his product; he should not guess at it.

Infrequent tests are not sufficient; you should test all the time. It costs less per lamp to test many than to test a few. The product of your factory may vary from day to day or from week to week, and you should detect these variations by tests before you pile up a large stock of the poorer quality. It is easier to sell a good lamp than a poor one. Not only is your business extended, but the growth of the electric lighting business as a whole is increased by a betterment of the various parts of the system. If you are not producing as high a grade of goods as your competitors, you should know where the fault lies, and the only way to know is to test, test, test until you discover the weak link in your chain of processes and apply the remedy that will bring your goods up to the highest standard. When you have reached that point, do not cease testing, for it is easy to slip back or for others to pass you in the race for superiority.

Perhaps you are quite sure that you are making the highest grade of goods and that the other fellow is taking your trade only because he has a better selling organization or certain commercial relations beyond your reach, and you imagine that testing would add to your costs in greater ratio than to your benefit. A sad delusion, I assure you, which will not help you in the race. Make your product as good as his, or better; prove your position by rigid tests, and your sales manager will soon see the result in increased business.

To the manufacturer tests are of great benefit and are as necessary to a secure future as careful accounting; but to the intelligent purchase, tests are even more necessary. How else than by testing can you know that the claims of a saleman are fulfilled by the goods? By what other means can you prove that the specifications under which you purchase are fully met by the manufacturer or seller? Will not the goods sold to you be more care-

fully selected if the shipper knows that they must pass certain tests before they will be accepted? Indeed, yes.

Experience proves that careful buyers who test everything obtain better goods for the same money than careless purchasers who buy on faith, without tests. No manufacturer's average product equals his best. In placing a first-class article upon the market he must make a fairly good average product and then eliminate the weak units. Do your purchases of electrical supplies and apparatus include the satisfactory together with the unsatisfactory product of some manufacturer or do they include only the former? If only the former, then I venture to say that you are purchasing subject to test.

No better evidence than the truth of this assertion can be found than the practice of the great Pennsylvania Railroad Company. That corporation buys practically nothing without rigid tests, and it maintains at Altoona, Pa., an extensive laboratory devoted to the testing of everything which enters into the construction of its locomotives, rolling stock, tracks, bridges, buildings, telegraph and signal systems, and everything pertaining to its equipment and supplies. If continuous testing did not pay well for the great expense and effort, the company would have discontinued it years ago.

To-day you cannot sell a barrel of oil or an incandescent lamp, a car axle or a boiler plate at any price to the Pennsylvania Railroad Company unless it passes all of their tests. This most careful purchaser obtains not only the best of everything, but it obtains the cream selected from the best, every time and all the time, for it constantly tests everything it buys and rejects all that is not up to specifications, accepting only that which tests out correctly.

Another instance is that of the United States Navy Department, particularly the Bureau of Equipment, under whose jurisdiction all electrical supplies and apparatus for the naval vessels, yards and stations are purchased. All contracts are made under very rigid specifications, but many a manufacturer has learned a hard lesson by accepting a contract under the impression that the specifications were simply government "red tape," or with the idea, born of self conceit, that his product was "all right" and required no testing before being submitted to make sure it would comply with the specifications.

Many thousands of dollars' worth of wire, cable, fuses, conduit, lamps, supplies, motors, generators and electrical apparatus is rejected every year by the Navy Department, as a result of their tests, for failure to conform to their specifications. In most cases the cost of transportation alone of the rejected material, aside from the money loss, would have paid for proper tests. Incidentally you can rest assured that this rejected material does not in every case go into the manufacturer's scrap heap. Somebody who does not test may get it, perhaps at what looks like a bargain at first, but how costly at last.

The great importance of testing has been demonstrated through a series of years by the largest manufacturers and purchasers to their entire satisfaction, and has so impressed other manufacturers and purchasers that a considerable demand exists for commercial testing. To meet this demand testing laboratories have been equipped, where, for a reasonable price, anyone may obtain the results of careful tests made by acknowledged experts.

The value of tests lies in their accuracy and impartiality. The demand is for cold-blooded tests made by disinterested experts who care only for facts accurately determined. Such tests, honestly reported without fear or favor and carefully guarded as the property of the customer for whom they are made, are of considerable value both to manufacturers and to purchasers.

This recognition of the value and importance of testing is the cause of the equipment and maintaining of the Electrical Testing Laboratories, employing skilled experts and well trained technical assistants. In these laboratories tests will be made for your exclusive benefit at a reasonable cost. Here testing facilities, which otherwise would be within the reach of but few, are at the command of all. The cost is for the work done, and is not a constant tax, as would be that of your own laboratory. With such facilities at your command is there any excuse for reckless manufacturing or careless buying?

It is highly important to the central station and the isolated plant to keep all instruments in check. The life of incandescent lamps depends greatly upon the accuracy of the voltmeter indicating the "pressure" supplied to them. An inaccurate volt indicator is often the cause of excessive cost of lamp renewals. To correct such an instrument costs far less than to continue to pay for its errors. If you have many voltmeters to keep in check, and are too far from a testing laboratory, buy an approved type of portable potentiometer and keep your instruments in check with it.

The importance of frequent testing is illustrated by a case which recently attracted our attention. A certain large lighting company having a well operated meter department, periodically sent their standard ammeter to an electrical laboratory to be checked. Time after time it was found to check exactly right and was looked upon as a model individual, a "good and faithful servant," but one day recently it was again sent to us for a test and found to be inaccurate, and for no known reason. The meter department of that company would have suffered heavily if it had relied upon the previous good record of that instrument and had trusted to its established reputation for veracity. It is not wise to have too much faith or to be "cock sure," but it is the better wisdom to prove all things by frequent authoritative tests.

The importance of testing electricity supply meters is recognized by all wide awake station managers, yet how many keep their standard voltmeters and ammeters up to the necessary degree of accuracy?

The checking of such instruments is a considerable part of the business of the Electrical Testing Laboratories, for which work a generous equipment of standard instruments and reference standards are provided and maintained in precise agreement with government standards.

The Society of Chemical Industry

ITS FIRST MEETING IN AMERICA

THE first annual meeting of the Society of Chemical Industry ever held in America will occur in the city of New York on September 8, 9 and 10. Members will be present from all quarters of the globe. England will have the largest visiting delegation; Germany will be well represented; also Holland, Australia, India, and the Straits Settlements. Sir William Ramsay, especially in the public eye recently on account of his successful experiments with radium, heads the visiting scientists as the retiring president, and with him will come an array of men whose names are familiar among all the universities.

The Society of Chemical Industry is of English origin, with sections in all the Continental countries, the States and the colonies, and this is its first meeting in America. New York's selection as a place for the annual assemblage is in recognition of the growing numbers of the New York section and the high place its members have taken in the profession. To more fully express this admiration of the progress made by the New York

section the society in council has nominated William H. Nichols, president of the general council, as the next president of the society. Mr. Nichols, however, is not the first American president. Prof. Charles F. Chandler, D.Sc., LL.D., M.D., Ph.D., of Columbia University, was the first American to receive this honor.

The visitors will be the guests of the New York section while in this city, and on the trip which is to follow. On the general committee of arrangements for the entertainment of the visitors while in America appear the names of Professors Chandler and Marston T. Bogart, of Columbia University; Virgil Coblentz, professor of chemistry at the College of Pharmacy; Thomas A. Edison, Dr. Ernst J. Lederle, A. C. Humphreys, president of Stevens Institute; R. W. Moore, chief chemist of the local United States Customs; F. G. Zinsser, of Flushing; William Jay Schieffelin, and R. C. Woodcock. H. Schweitzer, of 40 Stone Street, is chairman, and T. J. Parker, of 25 Broad Street, secretary.

Business sessions, visits to manufacturing establishments, and excursions to points of interest will occupy the members' attention for the three days they are in New York. The retiring president, Sir William Ramsay, K.C.B., DSc., LL.D., F.R.S., will deliver the president's address on Thursday, September 8, at Havemeyer Hall, Columbia University. On September 12 the New York section will take its guests aboard a special train for a tour of the country as far West as St. Louis, with stops at several of the larger manufacturing plants. Philadelphia will be first visited, then Washington, and after a stop at Pittsburg the train will continue directly to St. Louis, where a special programme of five days' entertainment has been mapped out. There will be two and three-day stops at Chicago, Milwaukee, Detroit, Niagara Falls and Boston, and the train will arrive back in New York on September 30.

Wireless Telegraphy in the Russo-Japanese War

THE correspondent of the London "Times" who was in charge of the De Forest wireless telegraph installation on the steamer cruising off Port Arthur, some time ago, sent to his paper a letter giving an account of his experiences. In testing the apparatus, a distance of 150 miles in both directions was reached in calm weather, while at other times 125 miles was the greatest distance attainable, owing to the rolling and jarring of the vessel. The apparatus was grounded to the hull and a 4-wire antenna was used a little less than 100 feet high.

"With the repaired pole on the shore station," writes the correspondent, "we have a scant 150 feet of antenna The site is on the top of a cliff, about 150 feet above the sea, with a rocky hill sloping sharply to one side, rising higher than the pole. I forgot to mention that we are on an island 1½ by 2 miles in area—a mass of rocky hills rising several hundred feet above sea-level. The site we have is the best procurable on the island—Liukungtao —and there is no suitable site on the mainland within 4 or 5 miles of the office.

"The country is full of wireless, and we have any amount of competition, not in press work, however. All the British warships, from the third-class cruisers up, are equipped with Marconi, about twenty-four in all; nearly all the Japs have wireless equipment; the Russian ships are equipped, and several German vessels. One or another of them can be heard at any time, day or night. The Japs are particularly numerous, and we are at it all the time.

"We laugh at them, for we have struck some good points in tuning, which settle them very nicely. On the boat, when receiving our stuff, two of the four wires are grounded directly, which gives best results. Any resistance between those wires and the ground weakens the signals. If we want to hear the Japs call, disconnecting ground wire entirely from syntoniser of the receiver brings them in strong; while with the ground wire on, as in receiving our stuff, the Japs come very faintly.

"On the shore station it is different. Three wires are best in receiving up to 100 miles, with the other two wires free, at which time the Japs come in weakest. By grounding the other two wires the Japs come in very strong and our stuff weakest. Above 100 miles our stuff comes best with two wires grounded directly. That, of course, allows others to come in, but they are not strong enough to prevent my reading through. So far, that tuning is best, and gives very satisfactory results.

"There are always one or more British warships lying here, and we have them all wondering. The lieutenants of two torpedo boats have told me they do not depend on more than 40 or 45 miles regularly, and another says he can depend on 60 miles. The last one has 160 feet of wire to do his 60 miles, while our boat has a scant 100 feet of wire, and easily covers more than double the distance. Our speed is a source of wonder and admiration to these British officers. I saw some of their tape after we got through with it, and could not read a word."

German Electrical Industries

THE second part of the annual report of the Frankfort Chamber of Commerce for the year 1903 has just been published. According to a recent consular report, it includes a statement made by the Lahmeyer Electric Company that the increased activity of Germany's industries during 1903 has had a corresponding effect upon the company's business and that of the electric branch of Germany generally."

This, however, did not bring about the long longed-for advance in prices and profits, as competition continued exceedingly keen. Many orders were filled without profit, and many times goods were sold for less than the cost of production. The reason for this is to be found in the efforts of the great electric companies to give as much employment as possible to their plants, which had been considerably extended and enlarged.

Another cause was "the competition arising from the growth of native electric industries in many foreign countries which heretofore had been profitable markets for German electric goods. The strong effort made by these domestic electrotechnical works to crowd out German supplies compelled German exporting concerns to offer exceedingly low terms in order to maintain their footing in these foreign countries. The high price of raw materials was also an obstacle under the above-noted business conditions. The prices of some of the raw materials advanced toward the close of the year; among these were copper, brass and dynamo wire. Owing to the establishment of a trust the prices of incandescent lamps has been raised 50 per cent."

Metallic calcium, manufactured on a commercial scale by a new electrolytic process, has a great affinity for oxygen, which should make it a very desirable innovation in the iron industries. It is harder than lead, can be hammered into leaf and is very light, having a specific gravity of only 1.58, as against 2.68 of rolled aluminium.

The Development of the Galvanometer

By J. WRIGHT

THERE is probably no piece of electrical apparatus which has been so developed and perfected during the last few years as the galvanometer. This may be defined as an instrument for measuring the strength of an electric current by the reactive force exerted between a magnet and a coil of wire through which the current to be measured is passed, one of the two elements, either the magnet or the coil, being fixed and the other movable. Starting with the simple galvanometer or detector, consisting of a compass needle surrounded by a few turns of wire, we now possess delicate pieces of apparatus in which the movable element is supported by an almost invisible thread of cocoon silk, and so sensitive that they are capable of measuring the current produced by pressing two dissimilar coins together in the hand.

As far back as 1802, Romagnosi made a discovery which, though not published at the time, was rediscovered later, and culminated in the production of the galvanometer. Romagnosi's discovery related to the disturbing effect exercised on a magnetic needle by a voltaic pile or battery. It remained for Oersted, of Copenhagen, in the year 1819, to demonstrate the fact that a magnet tends to set itself at right angles to a wire through which an electric current is passing; further, he showed that the direction of displacement of the magnet depended upon the position of the wire, whether above or below the needle, the direction of the current being constant. With very simple apparatus, Oersted's original experiment can be repeated by any would-be investigator of the principles underlying galvanometer construction. He took an ordinary pivoted compass needle, *NS*, Fig. 1, and held above it and parallel to it a wire, *AB*, connected to a battery or other convenient source of direct-current. On completing the circuit through the wire the compass needle was deflected, the direction of deflection depending on the direction of the current in the wire *AB*. Thus, if the current were flowing in the direction indicated by the arrow heads, from *A* to *B*, the north extremity of the needle would turn to the east, that is, away from the observer in Fig. 1, and vice versa. A little consideration will show that if the wire *AB* be brought around in a complete loop below the needle, the effects will be additive, and the resultant force upon the needle will be doubled. From this simple beginning to the well-known "detector" galvanometer, consisting of

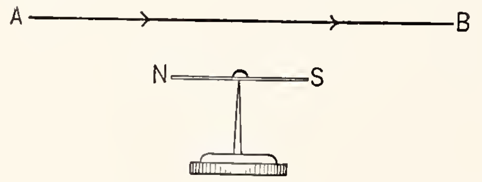


FIG. 1.

a rectangular coil surrounding a pivoted magnetic needle, was an easy stage, the first of its kind being known as Schweigger's "multiplier" from the fact that the effect of a single turn of wire upon the needle was multiplied by the number of turns in a coil.

The next development resulted in increased sensitiveness and consisted in nullifying the effect of the earth's magnetism upon the needle, thus rendering it entirely subservient to the magnetic effects of the coil itself. It was due to Nobili, who applied the principle of astaticism to Schweigger's multiplier, thus rendering it independent of the earth's magnetism, which normally causes the needle to set itself in the magnetic meridian. Nobili constructed a pair of exactly similar needles and mounted them rigidly on an axis of brass wire *W*, as in Fig. 2.

It will readily be seen that the effect of the earth's magnetic field on the one needle will be exactly counterbalanced by that on the other, and the "astatic pair" will therefore be free to move in any direction, according to the current passing round the coil *a b c d*, from the battery *E*, the effect on the upper needle being the same as that on the lower one. It is usual in later forms of the astatic galvanometer to surround each needle with a coil, the two coils being wound in opposite directions so as to exercise an additive effect upon the needles. Further sensitiveness was secured in Nobili's original instrument by suspending the astatic system through the medium of the wire *W*, from a fixed support by means of a fine silk fibre which reduced the friction due to the pivot and rendered the error from that cause practically negligible. The instrument was mounted on a suitable base provided with leveling screws and covered with a glass shade through which the deflections of the needle could be observed on a circular horizontal dial graduated in degrees.

We next come to the tangent galvanometer, in which the tangent of the angle of deflection of the needle is directly proportional to the current flowing through the coil. This result is dependent on the fulfilment of certain conditions which, omitting all theoretical considerations, are thus cited by Professor Ayrton:—

When (1) The needle is controlled by a uniform magnetic field.

(2) The diameter of the coil is large compared with the length of the needle.

(3) The needle is suspended sufficiently near the center of the coil that the field which is produced by the current passing round the coil, is a uniform one in the neighborhood of the needle.

(4)The axis of the needle is parallel to the plane of the coil when no current is passing.

In order to secure these conditions, the tangent galvanometer is constructed as follows:—A truly circular coil, *AB*, Fig. 3, from 10 to 15 inches in diameter, consisting of a single turn of thick wire, or a number of turns of fine wire, according for the purpose

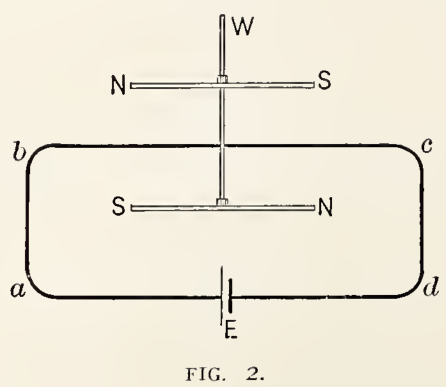


FIG. 2.

for which the instrument is required, is constructed, and, at the center of this coil, in a plane with it, pivoted a short magnetic needle, *NS*, from three-quarters of an inch to an inch in length. A light aluminium pointer is attached to the needle at right angles to it, and indicates over a horizontal scale graduated in tangents.

With a view to further securing uniformity of the field of a tangent galvanometer, Gaugain suggested placing the needle at a point on the axis of the coil, separated from the center of its plane by a distance equal to half the radius of the coil, whilst Helmholtz still further improved on this idea by constructing a galvanometer with two equal and parallel coils, the needle being placed on their common axis at a distance from either coil equal to half their respective radii. The ideal construction as suggested by Professor Sylvanus P. Thompson consists of three coils having a common axis, the center one being of larger diameter than the other two, which are equal, and surrounding the needle, which is thus, theoretically, at the center of a sphere whose surface is defined by the coils.

Following the suggestion of angular displacement conveyed by the tangent instrument, we come next to the sine galvanometer. Any galvanometer, the needle of which is controlled by the earth's magnetism, constitutes a sine galvanometer if provision be made for turning the coil about the axis of the needle. The method of usage is as follows:—The galvanometer is set up with its needle in a plane, *i. e.*, they are both in the mag-

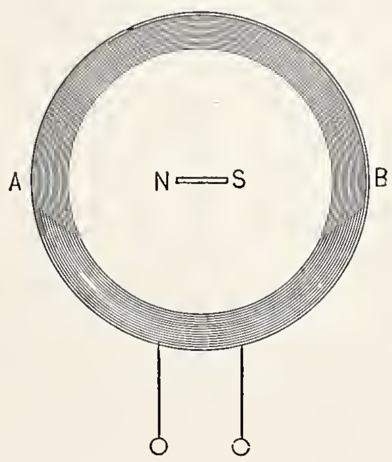


FIG. 3.

netic meridian. If now a current be caused to circulate round the coil, the needle will be deflected; the coil itself is then turned bodily round in the same direction as the needle, while the current is flowing, and at a certain point overtakes the needle, and again lies in a plane with it. The sine of the angle through which the coil has been turned to effect this, is then a direct measure of the current passing round the coil.

The next important stage in the development of this useful piece of apparatis is to be found in Sir William Thomson's (now Lord Kelvin) mirror or reflecting galvanometer, which was first devised as an aid to submarine cable signaling, where the currents dealt with were often so slight as to defy detection by all ordinary forms of instrument. The mirror galvanometer, as originally constructed, consisted of a small concave mirror, about three-eighths of an inch in diameter, to the back of which were attached three or more short pieces of

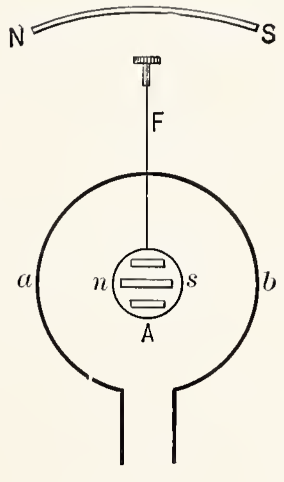


FIG. 4.

magnetized watch spring *n s*, Fig. 4. This light combination was suspended from a fixed support by means of a single fibre of unspun cocoon silk, *F*, in the center of a coil, *a b*. Its normal position was controlled, and the earth's field counteracted, by a controlling magnet, *NS*, adjustably arranged on a vertical support above the coil. The indications of this instrument were read by means of a reflected spot of light, which, emanating from a suitable source such as an oil, gas or electric lamp, was condensed by means of a suitable lens, and projected on to the mirror, whence it was reflected back on to a graduated horizontal scale in the shape of a rectangular or circular spot of light. The requisite definition is obtained by means of a fine black wire or thread stretched across the lens or aperture of emission, as a vertical diameter of the spot, and it is by the coincidence of this line with the divisions on the scale that the deflections of the magnetic system are recorded.

Here we have an extremely light, movable element suspended by a practically frictionless support, and the length of whose index is limited only by the intensity of the illumination and the focal length of the mirror *A*, which may be as great as 6 feet or even more.

The astatic principle has also been applied to the mirror galvanometer, two sets of exactly similar magnets being constructed, one of which is attached as before to the back of the mirror *A*, Fig. 5, while the other set, with their poles pointing in an opposite direction, is mounted on a light, coffin-shaped mica vane, *B*. The two structures, *A* and *B*, are symmetrically and rigidly mounted on a vertical aluminium wire, *W*, and suspended, as before, by a quartz or silk fibre *F*. Two similar coils, wound in opposite directions, surround the mirror *A* and the vane *B*, respectively, and the latter is arranged in close proximity to the sides of a similarly shaped chamber, which can be completely closed or partly opened at will, thus regulating the motion of the air contained in it. In this capacity it acts as an adjustable damping device, whereby the oscillations of the suspended system are reduced to a regular and consistent period. Like the foregoing instrument this also is provided with a controlling magnet, *NS*, whereby its sensitiveness and normal position can be controlled and regulated.

It is obvious that galvanometers of the above type, with freely suspended magnetic systems, are unsuitable for use on boad ship where the rolling of the vessel renders it impossible to maintain the system vertical. With a view to overcoming this difficulty, Lord Kelvin, then Sir William Thomson, designed his marine galvanometer, in which the mirror with its attached magnets, is suspended from above by a silk fibre as in the ordinary type, while a second fibre, attached to the lower edge of the mirror, is secured to a light fixed spring which keeps the two fibres taut. The whole suspended system is fitted in a removable metal slide by means of which it can be bodily withdrawn when repairs are necessary.

Despite the great delicacy and utility of these instruments, they have one very serious drawback which materially combats their more universal

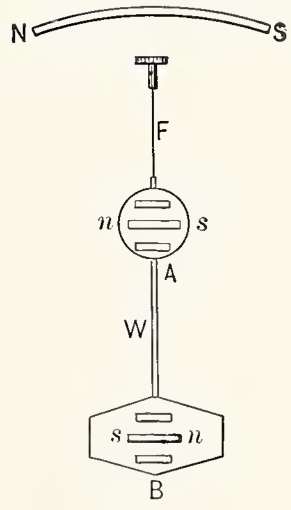


FIG. 5.

adoption in practice; it consists in their extraordinary susceptibility to external magnetic influences, such as arise from moving masses of iron and magnetic material in their vicinity. Numerous efforts have been made to overcome this difficulty by completely surrounding the instrument with a thick shield or case, also of iron, designed with a view to intercepting the disturbing magnetic lines of force and

thus preventing them from reaching the suspended system. A shield of this description constitutes a feature in the construction of the Thomson marine galvanometer described above. The remedy is, however, only partially successful, and frequently introduces

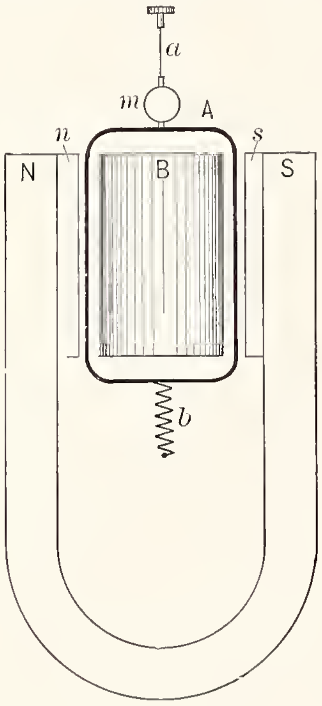


FIG. 6.

further trouble by accidental magnetization of the case itself. The real remedy, and one which is now being almost universally adopted, is that of reversing the fixed and movable elements of the galvanomenter, thereby converting it into an instrument of the so-called d'Arsonval type, named after its inventor. In these instruments a light rectangular coil of very fine wire, *A*, Fig. 6, is suspended between the poles of a powerful steel horse-shoe magnet, *NS*, the magnetic circuit being rendered as complete as possible by the addition of semi-circular shaped cheeks or pole-pieces *ns*, which practically surround the coil, and a laminated cylinder of soft iron, *B*, which is rigidly supported inside the coil and serves to complete the magnetic circuit with the exception of the two air spaces left for the free movement of the coil.

The current to be measured is led into and out of the coil by way of the suspensions, which consist of a fine phosphor-bronze ribbon, *a*, at the top, and a loosely coiled spiral of the same material, *b*, at the lower end. The coil *A* is wound on a light rectangular frame of ivory or aluminium; if the latter, it must be divided at one point by an insulating piece, or air gap, or the induced currents set up in the frame itself will make its movements very slow. This fact is made use of in what are known as "dead beat" instruments, in which the metal frame forms a complete electric circuit, or, in default, a few turns of the coil itself are short-circuited upon themselves. The motion of the coil under the influence of a current passing through it, is thus rendered very deliberate, and is automatically checked on reaching the zero point of the scale.

As in the Thomson form of reflecting galvanometer, the mirror *m* is attached to the suspended system at a point just above the coil, and the usual lamp and scale provide a ready means of reading the deflections.

There are several excellent patterns of this instrument on the market and it has, in fact, been brought to such a pitch of perfection that it now rivals the Thomson instrument in the field of sensitiveness.

Sullivan's universal galvanometer is a very excellent pattern of this type, and, as its name applies, is adapted for a multiplicity of uses, either on sea or land. The permanent magnet is circular, and is arranged horizontally on a substantial base, being provided with a gap for the reception of the coil. The latter, with its soft iron center, is mounted in a frame which fits into convenient slides in the body of the instrument, providing a ready means of inspection and renewal, and making the magnet and body of the apparatus available for the various purposes for which it is designed, by simply taking out one frame and substituting another; in fact most modern types of d'Arsonval galvanometer have their coils arranged on this principle.

For stationary use on land, the suspensions are similar to those described in connection with Fig. 6, the upper ribbon being attached to a tension screw. For use at sea, however, it is obvious that the suspension must be absolute, whatever the position of the instrument as a whole, and the lower ribbon is consequently straight, attached to, and kept taut by an adjustable spring. Camel-hair brushes, fitted to the frame, and bearing on the suspensions, form an admirable damping device, and it is claimed that, with this instrument, it is possible to obtain reliable readings on board a torpedo boat going full speed ahead—no mean gauge of its capabilities as the experienced reader may well imagine.

Reverting to the original type of instrument, in which the magnets themselves constitute the moving element, we come now to a type which is not often met with in every-day practice, namely the ballistic galvanometer. In dealing with electric currents of very brief duration, such as the electrostatic charges in a condenser, or a long length of submarine cable, we have to cope with a condition of things for which the ordinary forms of instrument are totally unfitted, in that they are incapable of responding in so brief an interval of time, except by an irresponsible swing of the moving system, which takes place too rapily to be of any assistance as a record. To meet this difficulty, the ballastic galvanometer was designed. The magnets, instead of being straight like the watch-spring variety in Lord Kelvin's instrument, are made thimble-shaped as at *A*, Fig. 7, which represents an enlarged elevation and section of one of the magnets. They are of steel, hollow in the center as shown and provided with a saw-cut along the greater part of their length, which converts them into miniature horse-shoe magnets with semi-cylindric limbs. The object of this construction is to provide for as little air resistance as possible during the movement of the suspended system, which, as it does not take place until the current causing it has practically ceased, is a very necessary provision. Four of these magnets, equal in size and degree of magnetization, are mounted, as shown, on a vertical aluminium wire, *W*, so as to form an astatic system, two of them being together at the center of the coil *a b*, and the remaining two at short distances apart, but in close proximity to the edges of the coil. The mirror *m* is fixed in its usual position, just above the coil, and the system is suspended, as in the ordinary type of instrument, by the fibre *F*. Transient electric currents, such as those resulting from electro-magnetic induction, are readily measured by the aid of

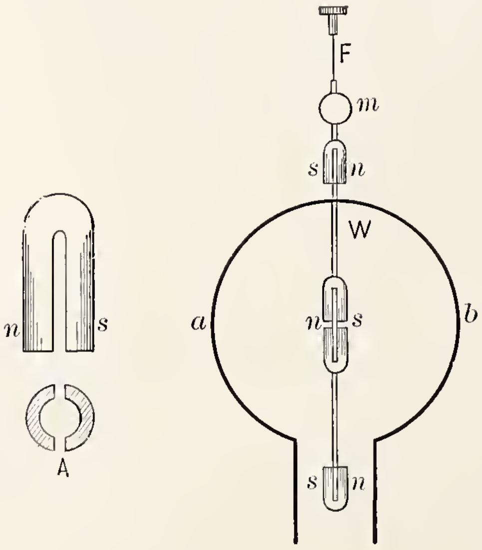


FIG. 7.

this instrument, which depends for its action purely upon the inertia imparted to the magnets *n s*, during the extremely brief duration of such currents.

We have already discussed the "dead-beat" principle as applied to galvanometers of the d'Arsonval pattern, and it may interest the reader to learn that this convenient method of

control has also been applied by Lord Kelvin to the ordinary mirror galvanometer though the method of obtaining that quality is rather different. The mirror, with its attached watch-spring magnets, is suspended by a very short fibre, inside a cylindrical tube slightly larger in diameter, there being just sufficient clearance to allow the mirror to swing freely. The inside of this tube is threaded from both ends, to receive two small screwed bezels, fitted with circular glass discs; when these are screwed into position the mirror is enclosed in a practically air-tight chamber, and is therefore put to the necessity of displacing a certain small volume of air in its every movement. The friction thus set up is just sufficient to exercise the necessary damping effect, and the suspended system, on being subjected to the current flowing round an encircling coil, swings slowly round to the limit of its deflection and back again to the zero position without any further oscillation about that point as in the ordinary form. Additional damping effects are sometimes secured by filling the closed chamber with paraffine oil, which slightly reduces the sensitiveness of the device.

A long-range, or, as it is sometimes called, cosine galvanometer, was the independent invention of Dr. E. Obach and Professor John Trowbridge, who made the discovery unknown to each other in 1871.

In construction it somewhat resembles the tangent galvanometer already described, with the exception that the coil or ring is capable of rotation round a horizontal axis or diameter, its angle of inclination being recorded upon a quadrant scale. On due consideration it will be seen that the magnetic influence of the current flowing round the coil, upon the needle, can be varied from a maximum when the coil is vertical, to a minimum or zero effect when the coil is horizontal, and therefore in a plane with the needle.

The fundamental principle of this galvanometer is based upon the law that the strengths of the currents flowing round the coil are directly proportional to the tangents of the angles of deflection of the needle, multiplied by the corresponding secants of the angles of inclination of the ring.

A further detail in its construction affects a point which, at first glance, is apt to be overlooked, viz., tendency of the needle itself to dip with the corresponding inclination of the coil. This is prevented by mounting the needle, of bi-conical form, on a long, light, vertical axis, fitted at its lower extremity with a small cylindrical metal weight, which, while adding very slightly to the inertia of the system, suffices to absolutely prevent any actual movement other than in a horizontal plane. A light vane attached to the axis, and playing in a shallow cylindrical chamber, provides the necessary damping effect.

This completes a brief category of the principal types of galvanometer in use up to the present day, with the general outlines of their various constructional principles.

Steam Turbine Progress

It has already been announced that the immense power station of the Pennsylvania, New York and Long Island Railroad and the Philadelphia Rapid Transit Subway system of Philadelphia are being equipped with steam turbines, aggregating at the start 33,000 K. W. capacity; but of more immediate interest is the fact that the Interborough Rapid Transit Company, of New York, and the Brooklyn Rapid Transit system have both adopted steam turbines of the Westinghouse-Parsons type for extensions in power. The equipment of these systems will be in units of 5500 K. W. each, thus conforming to the precedent established by the Pennsylvania and Philadelphia systems in regard to the capacity of their largest main generating units.

The Philadelphia Rapid Transit Company have also recently extended their original order for 16,500 K. W. in Westinghouse-Parsons turbines by 6000 K. W. in four units of 1500 K. W. each.

In the electric light and power field, the activity in steam turbine introduction still increases. Two 1000 K. W. Westinghouse-Parsons turbines will form the additional equipment to the present power system of the West Virginia Pulp & Paper Company, at Piedmont, W. Va.

The United Electric Light Company, of Springfield, Mass., have contracted for a 1000-K. W. Westinghouse-Parsons unit for their power station at Springfield, and a contract has been closed with the Merchants' Light, Heat & Power Company, of Indianapolis, Ind., for two 750-K. W. turbine units for general light and power service. The Iowa & Illinois Traction Company, of Clinton, Ia., also will shortly install two 400-K. W. Westinghouse-Parsons turbine units for furnishing aditional power to their present railway system.

An installation of peculiar interest as being the first to be placed in service in American mining work will be that of the Newhouse Mines & Smelter Company, who will install two 400-K. W. Westinghouse-Parsons turbine units at their Cactus Mines, near Frisco, Utah. Turbines will furnish electric power for lighting the buildings and mines, and for all kinds of power throughout the entire property.

It may be interesting to note here that Messrs. Deane & Main, consulting engineers, of Boston, have made a series of tests of one of the Westinghouse-Parsons 400-K. W. steam turbines at the works of the Westinghouse Machine Company, East Pittsburg. With a rated brake H. P. of 580 and a rated speed of 3600 revolutions per minute, the folowing results were obtained with approximately 100 degrees F. superheat: With 31 per cent. overload, 758.9 horse-power, the weight of steam per brake H. P. was 12.07 pounds; with 2 per cent. overload, 12.41 pounds; with 77 per cent. load, 12.86 pounds, and with 41 per cent. load, 14.62 pounds. With approximately 180 degrees superheat and 32 per cent. overload, the weight of steam used per brake H. P. was 11.17 pounds, and with 2 per cent. overload, 11.45 pounds. With dry saturated steam the following results were obtained: With 26 per cent. overload, 13.63 pounds; with 2 per cent. overload, 13.91 pounds; with 77 per cent. load, 14.48 pounds, and with 42 per cent. load, 16.06 pounds.

A Wireless Electric Typewriter

A WIRELESS electric typewriter is a recently proposed novelty. The transmitting machine consists essentially of a disc rotating in synchronism with a similar disc at a receiving station. Electro-magnets on the disc, one for each letter, are controlled by the typewriter keys. Pressing down a key on the transmitter operates a lever which engages with a certain contact piece on the rotating disc when the latter is in a definite position, contact is made, the magnet is excited, and the letter is printed. At the same instant an electric impulse is sent into space. This is received by the other instrument, and, the disc on the latter being in a similar position to that on the transmitter, the letter is again printed. By means of a controlling key the apparatus at the receiving station may be started or stopped simultaneously with that at the transmitting station.

The advantages of such a machine, should it prove commercially successful, are considered to be manifest. In these days time is of great importance, and with this instrument a saving of two-thirds of the time of transmission is claimed over that of the wireless telegraph.

Current-Collecting Devices in Third-Rail Practice

By J. EUGENE WALLACE

TO Europe belongs the honor of having had the first electrically operated railway that could be called a practical system for commercial uses, and since the trolley, as now used, had not been thought of, a third rail between the track rails was employed to supply energy to the moving car. In 1879, Messrs. Siemens & Halske installed an experimental third-rail system at Berlin; and in 1881 they opened to the public at Lichterfeld the first commercial electric road. Two years later another road was completed at Portrush, Ireland, also using a third rail between the track rails.

FIG. I.— A CAR ON WILKESBARRE & HAZLETON RAILWAY, PENNSYLVANIA

While Messrs. Siemens & Halske were thus busily engaged in Europe, Stephen D. Field, in America, was also occupied with the problem of electric traction, and through his efforts an exhibition road was built in 1883 for the Chicago Railway Exposition, a third rail again being used. This system also was employed in the line built at Baltimore in 1885, under the supervision of Mr. Leo Daft.

Up to that time there was no system adapted for use in a city street and the suggestion of the conduit method is credited to Mr. Field. In 1883, the Bentley-Knight Company, afterwards absorbed by the General Electric Company, started in Cleveland, Ohio, the construction of a conduit which was not a success, largely for mechanical reasons. This attempt was followed in 1888 by another one in Boston, which, for the same reasons, also proved a failure.

The first conduit to operate with success was opened in Buda Pesth, Hungary, about 1889, the operating potential being 350 volts. More recently, when the problem of electric traction in the city of New York was placed in the hands of Mr. F. S. Pearson for solution, the city authorities would not consider the overhead trolley, so that the only alternative was the conduit. With the aid of such information from Buda Pesth as was valuable, a conduit was built that gave satisfactory service with 500 volts. In this connection, Mr. Pearson, with no precedent to act upon, designed a power station that, although pioneer, ranks favorably with the large polyphase stations of more recent design.

About the latter part of the year 1884, Mr. J. C. Henry erected in Kansas City the first overhead system that could lay claim to being a practical one. He had two trolley wires on the top of which ran a small carriage drawn along by means of a flexible cable attached to the car. In 1885, an overhead system was installed in Toronto, Canada, by Van Depoele. In this the trolley wheel made contact on the under side of the wire as in current practice. This attempt does not appear to have gone beyond an experiment, and the honor of making the present American system of trolley contact a practical success belongs to Mr. Frank J. Sprague.

In 1887, Mr. Sprague took the contracts to run cars over a difficult route in the city of Richmond, Va., with the overhead trolley, and achieved success after meeting and conquering many difficulties, principally with the motors, rather than the trolley. The following year saw several roads using the trolley for commercial purposes. Except for improvements in mechanical details, trolley practice of the present day does not differ from that inaugurated at Richmond, in 1887, by Mr. Sprague.

In the opinion of the writer, the great success of the trolley can, in a large measure, be accounted for by the fact that the trolley wheel partially supports the wire, and thereby makes a very flexible contact. The best construction of the present day is designed to provide this feature at points of support as well as midway between supports.

Rigid trolley construction, such as has been sometimes used in subways and under elevated structures, does not give satisfactory results, as the bounding of the wheel on the rigid wire causes arcing and burning, which very soon affect the surface of the wire.

It will thus be seen that the trolley, which made the art such a success, was attempted only after the conduit had failed. Its development might, therefore, be called the third period of evolution. Human events are said to move in cycles, and evidently the cycle is complete, since in these latter days we find variations of the old third rail receiving much attention in connection with many new projects. In commenting on these three systems, we will consider them in the reverse order in which they originated and note some of their various merits and demerits.

Pioneers in electric traction objected to overhead construction, probably basing their objections largely on the undesirable appearance of overhead wires in streets, and the possible danger of their falling. The unde-

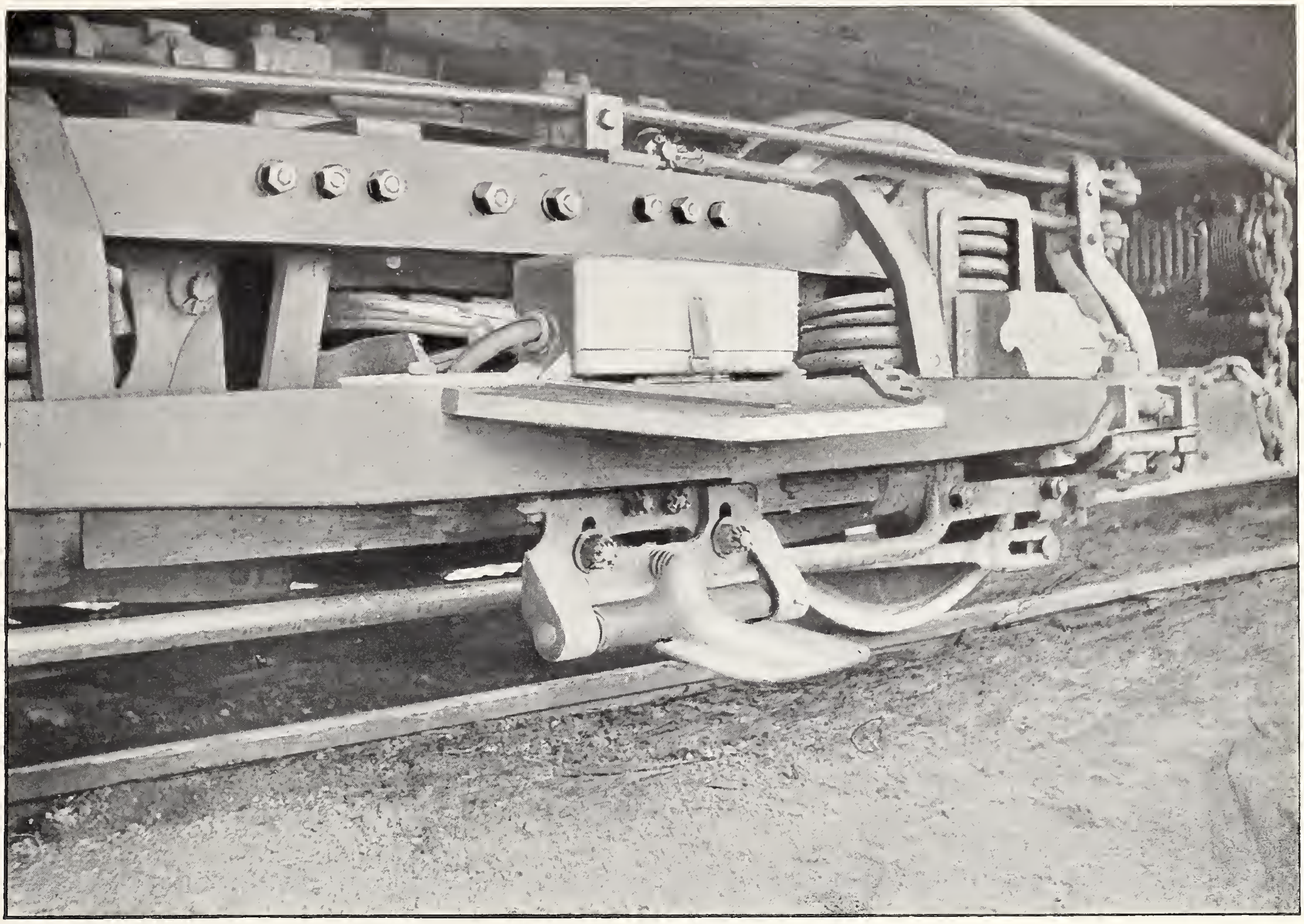


FIG. 2.—POTTER'S SLIPPER SHOE

sirable appearance of the wires overhead is still a drawback, but, thanks to under-contact, the danger from broken trolley wires has not proven, in practice, to be very great. Trolley wheels frequently slip off, and the pole sometimes knocks down construction that has been weakened by wear, or that was not well put up, but even this defect is being guarded against by the trolley retrievers now being put on the market. The retrievers will act when the trolley wheels slip and pull the trolley pole down clear of the wires.

If tracks and trolley are kept in first-class alignment, the trolley wheels will operate at quite high speeds with little trouble from slipping, but first-class alignment necessitates care in maintenance.

The ordinary trolley wheel cannot successfully collect from the wire more than 300 to 350 amperes without evidence of arcing and burning, and heavy, high-speed work calls for a greater current. In regions where sleet storms occur during the winter months, trouble is experienced with the sleet freezing on the trolley wire. Different expedients are used in various places to prevent this. One large traction company adopted the expedient of running cars under sufficient headway all night during sleet storms to keep the wire clear. During the day the ordinary schedule was sufficient. Another company, operating cars on a half-hour headway over one of its lines, found that taking the trolley wheel off and allowing the harp to scrape along on the wire gave them results in a measure satisfactory, since the cars could make their trips with reasonable comfort. Sleet is always troublesome in trolley practice.

The conduit for ordinary city traction at moderate speeds is, in many respects, an ideal solution of the problem of delivering energy to a moving car. Sleet storms have no effect nor have snow storms so far as the trolley contact is concerned, and electrolysis is easily avoided. Balanced against these advantages are high cost of construction and the troubles experienced with the plow, which reaches down through the slot to the conductors. Another feature not altogether pleasing is the necessity of losing contact for a few feet at crossings and turnouts, the cars having to cover the distance by momentum.

Inventors have been busy to devise systems that would give the advantages of the conduit with a cheaper construction cost, and the various button systems are some of the outcomes.

The third rail installed on the pioneer roads were between the track rails, and we have an illustration of old style practice quite near New York City on a branch of the New York, New Haven & Hartford Railroad, between New Britain and Berlin, Conn. Modern practice places the third rail outside the track rails to prevent brake beams from causing short circuits, and to make it possible to pass switches without losing contact. Third rails charged with a potential of 500 to 600 volts are somewhat dangerous, and roads using them operate on private rights of way usually fenced in. Inventors have also given this system much thought, a sectional third rail charged only when the car was over it being in nearly all instances the fundamental idea employed. Sleet troubles have not been given much thought.

In our northern country, where most of the third-rail systems are

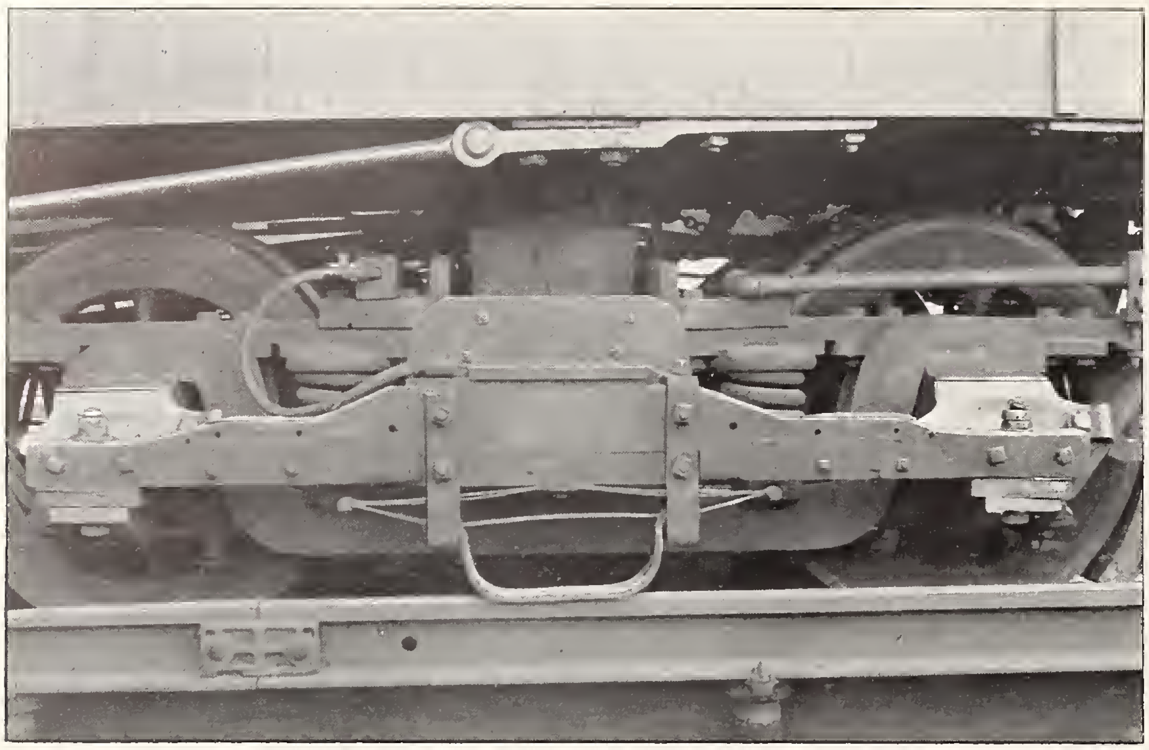


FIG. 3.—THE LINDALL SHOE ON THE BOSTON ELEVATED RAILWAY

found, sleet is, and has been, a great source of annoyance. In the city of Chicago, where the third rail was probably first installed in America, with the intention of depending on it for power at all times, sleet has always caused trouble during the winter months. Steel brushes were first tried, and then thin steel scrapers held upright at an angle of about 45 degrees across the rail were resorted to, but the latter were so rigid that they broke off. A return to steel brushes was made, and cars were run often enough during sleet storms to keep the rail clear. Snow causes no trouble on elevated railways.

In New York, during the past winter, steel scrapers, using a principle similar to that tried in Chicago were put on trial by the elevated roads. The scraper worked well so far as sleet was concerned, but broken scrapers caused many short circuits, and the noise produced when these scrapers were in operation was exceedingly unpleasant.

The third rail is more troublesome during sleet storms than the trolley, but it gives ample collecting surface for almost any demands that a car unit can make. It also allows running at any speed without danger of losing contact, is cheaper to maintain and is also cheaper in first cost for equivalent conducting capacity. This last item may in some cases be reversed if the fence inclosing the right of way is charged to third rail construction.

The type of shoe that has been standard in ordinary practice from early periods is the familiar link form. Originally the shoe was equipped with a spring to maintain contact, but in the operation of the Intramural Railway at the World's Fair in Chicago, during the year 1893, the springs were used up so fast that one day the supply ran short and the road had to operate without them, which it did quite successfully, and since then the spring has been omitted. At high speeds the link shoe bounds somewhat at joints and causes some sparking, but otherwise it works well if the rail is clear of ice and snow.

In the use of an unprotected third rail the only deviation of any note to the writer's knowledge, from the principle of the link form of shoe as originally laid down, is that quite recently put in service by the Boston Elevated Railway. The latter shoe as designed by Mr. John Lindall, of Boston, is illustrated in Fig. 3. It is quite light and is fitted with an elliptical spring which prevents noise and sparking, and being made of wrought iron, does not break easily. Several cars have been equipped with the shoe, and it has given excellent service. Springs of the elliptical form, as demonstrated by practice in Boston and in the New York conduit, seem able to stand the vibration caused by a moving contact.

Early in the year 1901, Mr. W. B. Potter, of the General Electric Company, equipped the experimental track maintained by the company at Schenectady with a protected third rail, the protection consisting of a steel channel beam held over the rail by brackets bolted to the ties. An illustration of the slipper shoe, as it is often called, designed for use on this protection rail, is shown in Fig. 2.

Mr. L. B. Stillwell, of New York, had given the third rail question some thought, and Mr. Potter's method of protection against sleet and accidental contact meeting his ideas, the general plan was adopted on the Wilkesbarre & Hazleton Railway, for which Mr. Stillwell was the engineer. On this particular road it was desired to be able to operate all steam railway equipment, including composite locomotives and pressed steel hopper cars, which made the location of the third rail a rather difficult matter to decide, since it was desired to avoid the moving from its running position of the contact (slipper) shoe when running through a paved street. Locomotive cylinders and car equipment crowded the location of the rail out and down. Clearing obstacles on a paved street demanded that the shoe go up, and a

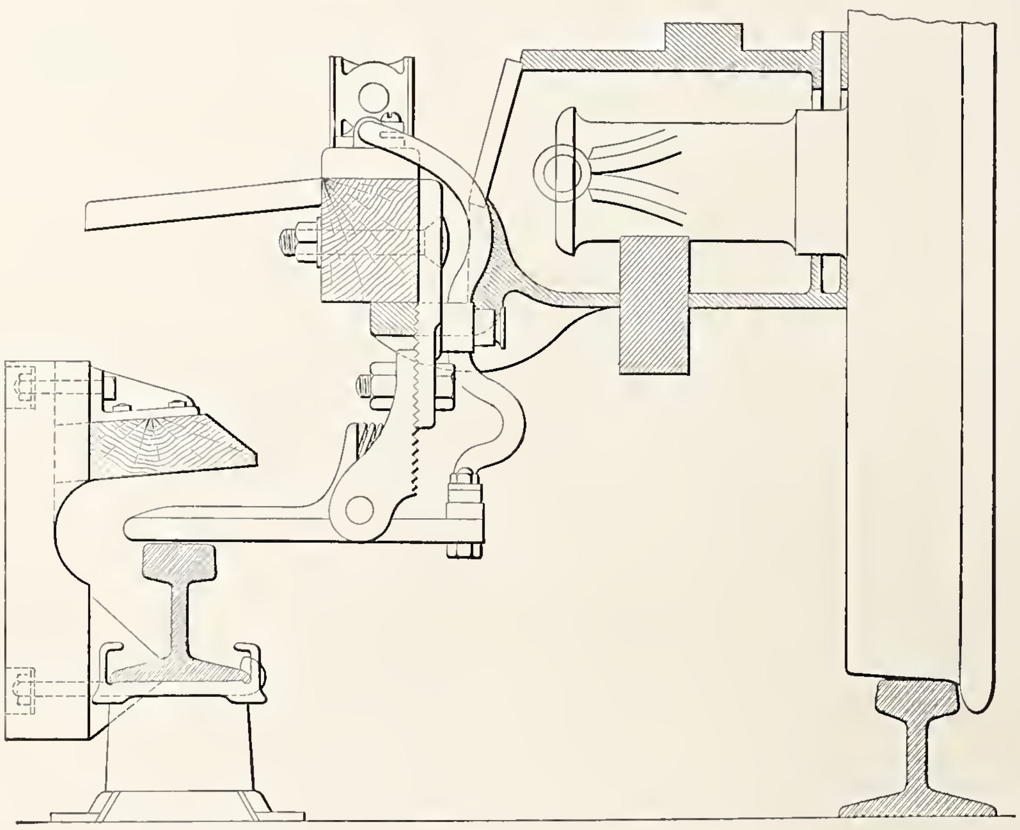


FIG. 4.—DETAIL VIEW OF CONTACT RAIL AND SHOE SHOWN IN FIG. 2

FIG. 5.—THIRD RAIL CONSTRUCTION ON THE WILKESBARRE & HAZLETON RAILWAY

desire to keep the shoe under the body of the car called for the rail location to come in towards the track.

A detail drawing of the compromise location and construction finally adopted is given in Fig. 4. Fig. 5 gives a further illustration of the construction involved in the protection, which, to meet local conditions, is very much changed from the original at Schenectady. The supporting posts are spaced 8 feet apart.

The contact rail is 28 inches from the gauge line, and the contact point is 5 inches above the top of the track rail.

The shoe, with a slight modification, is as originally designed by Mr. Potter. At high speeds the slipper shoe has very clearly demonstrated its superiority in operation, without sparking, over the old standard link shoe. The moment of inertia is small, and a spring so located that it does not get the full force of vibration, makes the shoe quick to respond to any imperfect alignment. Snow has less effect on the slipper shoe than on the old link type, owing to the fact that with the former there is no tendency to lift from dragging. This is equally true of the Lindall shoe. Rounding up the ends to prevent catching on joints and inclines gives the shoe a tendency to iron out the snow on top of the contact rail. This is objectionable for reasons that will be explained later.

The writer has never seen a sleet storm that drove down at a greater angle than approximately 30 degrees from the vertical. Assuming this to be the case, an angle of 45 degrees from the overhanging protection to the corner of the contact rail would give perfect protection from sleet. The experiences of nearly two winters of operation on the Wilkesbarre & Hazleton Railway seem to bear out this statement. This road operates in a mountainous country about 1500 feet above sea level, where driving storms are the rule. The angle from the corner of the overhanging protection plank to the inside corner of the contact rail is approximately 25 degrees.

At three points on the route for a short distance sleet has caused a little trouble during the past winter. These points were very much exposed, one being where the grade passed over the top of a mountain, and the other two at locations where conformation of the country caused a sweeping wind at right angles to the track. At these points the sleet formed on the inside corner of the rail, as shown in Fig. 6, causing the shoe to lift and lose contact. The trouble usually occurred on the first morning trip after several hours had elapsed since the passage of a car. It is believed that an angle of 45 degrees, which in this case locomotive cylinders did not permit, would have kept the sleet off the contact rail entirely. It is proposed next winter to tack canvas to the plank and supporting posts, and block up the space on the back side of the rail, so that no current of air can pass through between the rail and protection, with the hope that this will eliminate the sleet trouble at the three points mentioned.

In this method of solving the sleet difficulty a new condition in relation to snow became apparent. Where a bare rail is used for a conductor, plows and brushes can be resorted to with more or less success in removing snow from the contact rail, since it does not stick like sleet. The overhanging protection used in the system mentioned would not permit of this method of procedure. While cars have come in from schedule runs but slightly delayed during drifting storms when the snow filled in the space between the contact rail and the overhanging plank, the action of the slipper shoe in ironing out the snow was troublesome. Arcing occurred, which melted the snow, and the resultant water freezing on the rail gave the equivalent of sleet.

Here again Mr. W. B. Potter anticipated trouble, and devised a shoe shown in Fig. 7, for use during snow storms.

This shoe, as will be seen in the illustration, is nothing more than a triangle formed of $1\frac{1}{2} \times \frac{1}{4}$inch wrought iron. The triangle, held in a horizontal plane, slides along with the car, and the thin edge of the iron being against the rail, pushes snow both outward and inward. The contact area would seem small, but practice has not developed any trouble on that account.

Cars equipped with this shoe have passed through drifts 3 feet deep without the slightest difficulty. Cars equipped with the slipper shoe have also performed the same feat, but the

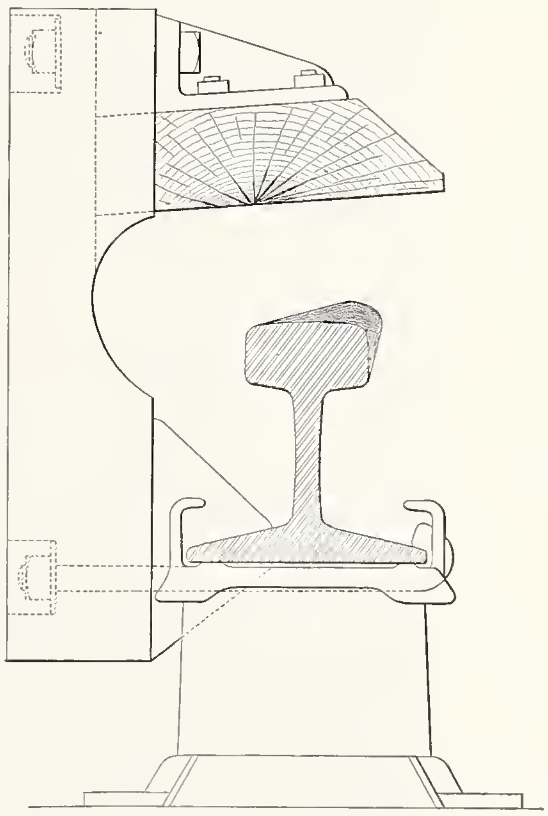


FIG. 6.—SLEET ON THE CONTACT RAIL

management does not allow them to do so continuously, for reasons already mentioned.

The writer believes these types of shoes worthy of adoption, even if a road does not use a protected rail. Driving snow storms, followed by cold, very often create drifts of snow that are very hard, and they would severely try the strength of brushes of

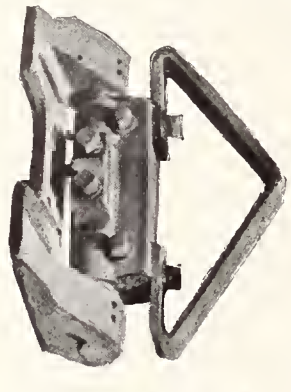


FIG. 7.—SNOW-STORM SHOE

the kind necessary with the old link type of shoe. The snow-storm shoe handles the situation very nicely and no brushes are necessary.

The snow-storm shoe is also quite efficient as a sleet cutter, it being found that a little additional pressure on the shoe by means of a pole enabled the cars to run over the three places previously mentioned where sleet drove in on the contact rail after a car had not passed for some time. The road has earned a very enviable reputation for running cars on time, in all kinds of weather, which is not true of all third-rail equipments.

During the construction period and the subsequent one of operation, there have been no accidents of any moment to discredit the location of a third rail along side of the track. Workmen on the track exercise no particular care around the rails; one would almost have to make deliberate effort to receive a shock. The only short circuit during construction was caused by a long, steel rope being thrown rather carelessly between the track rail and third rail. In the snake-like movements of the rope it made contact between the two rails.

In spite of warnings people will walk on the tracks of third-rail systems, but thus far no fatal results to such persons are recorded in connection with the Wilkesbarre & Hazleton Railway. This fact is not true of many bare third-rail systems The results of experience in connection with this road seem to prove that the element of personal danger from third rails is practically eliminated by the slight protection used.

Additional protection could be obtained by fastening a strip of wood on the inside of the contact rail just under the ball. This would prevent accidental contact when anyone is between the contact rail and the track rail. If one is outside the contact rail the shock received can only be from rail to ground, and in dry weather this is not dangerous, and on many soils not so very disagreeable; at least the writer has not found it so.

We are about to enter a new era in electric traction in connection with the use of single-phase alternating-current motors. For such systems engineers will probably find it expedient to use overhead construction for various reasons. Safety to human life would argue that the high voltage used on the trolley must be out of all reach of any possible accidental contact. Overhead construction will also make possible electrical operation over the intricate switching of a large trunk line railroad terminal. For high-speed work the trolley pole will probably be abandoned for a sliding contact of the bow form. Time will doubtless find a solution for any annoyance that may be experienced with the sleet question as involved in the use of high voltages for single-phase motors.

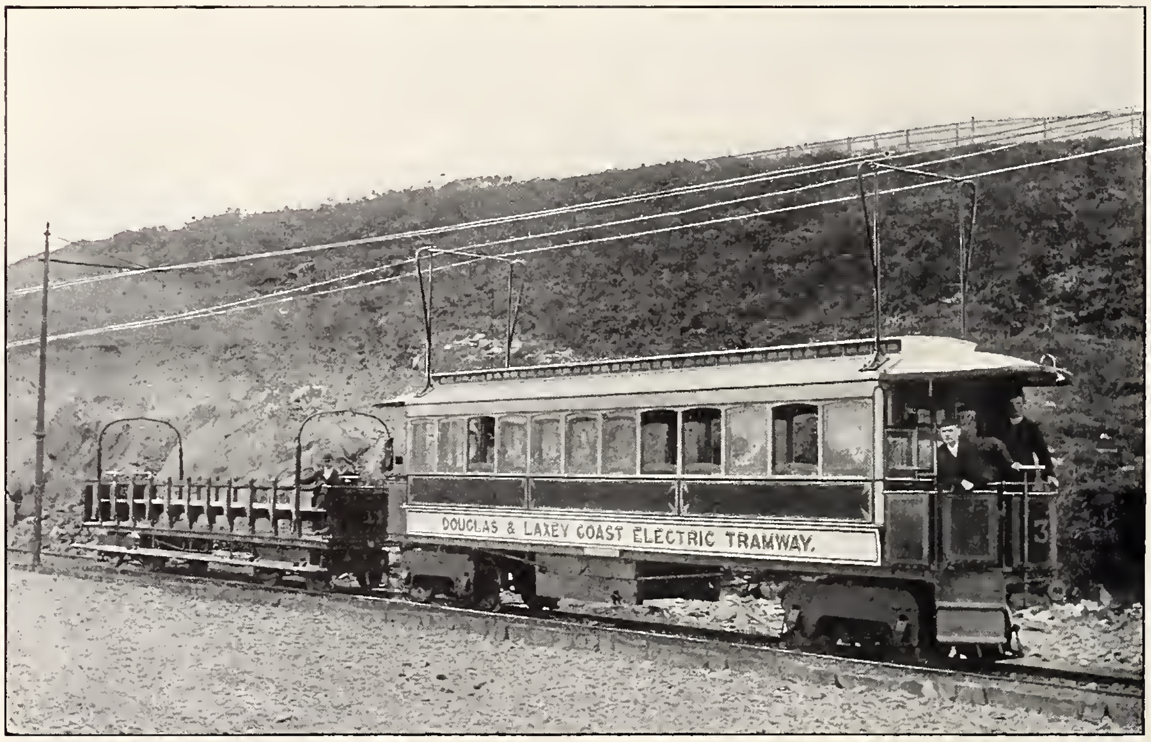
Foreign Overhead Current Collectors for Trolley Cars

IN connection with the preceding article on "Current-Collecting Devices in Third-Rail Practice," by J. Eugene Wallace, it may be interesting to refer also to the illustrations on this and the following pages of several different forms of overhead collectors exemplified on European electric railways. The way in which the current is carried from the overhead conductors, in fact, presents one of the very striking differences between British and American and Continental electric railway practice.

In both Great Britain and the United States roller contact is exclusively used, nearly always in the shape of the familiar small trolley wheel, though in a few instances, as, for example, on the Douglass & Laxey Coast Railway, in the Isle of Man, this wheel has been abandoned in favor of a roller of considerable width, or perhaps length would better express it.

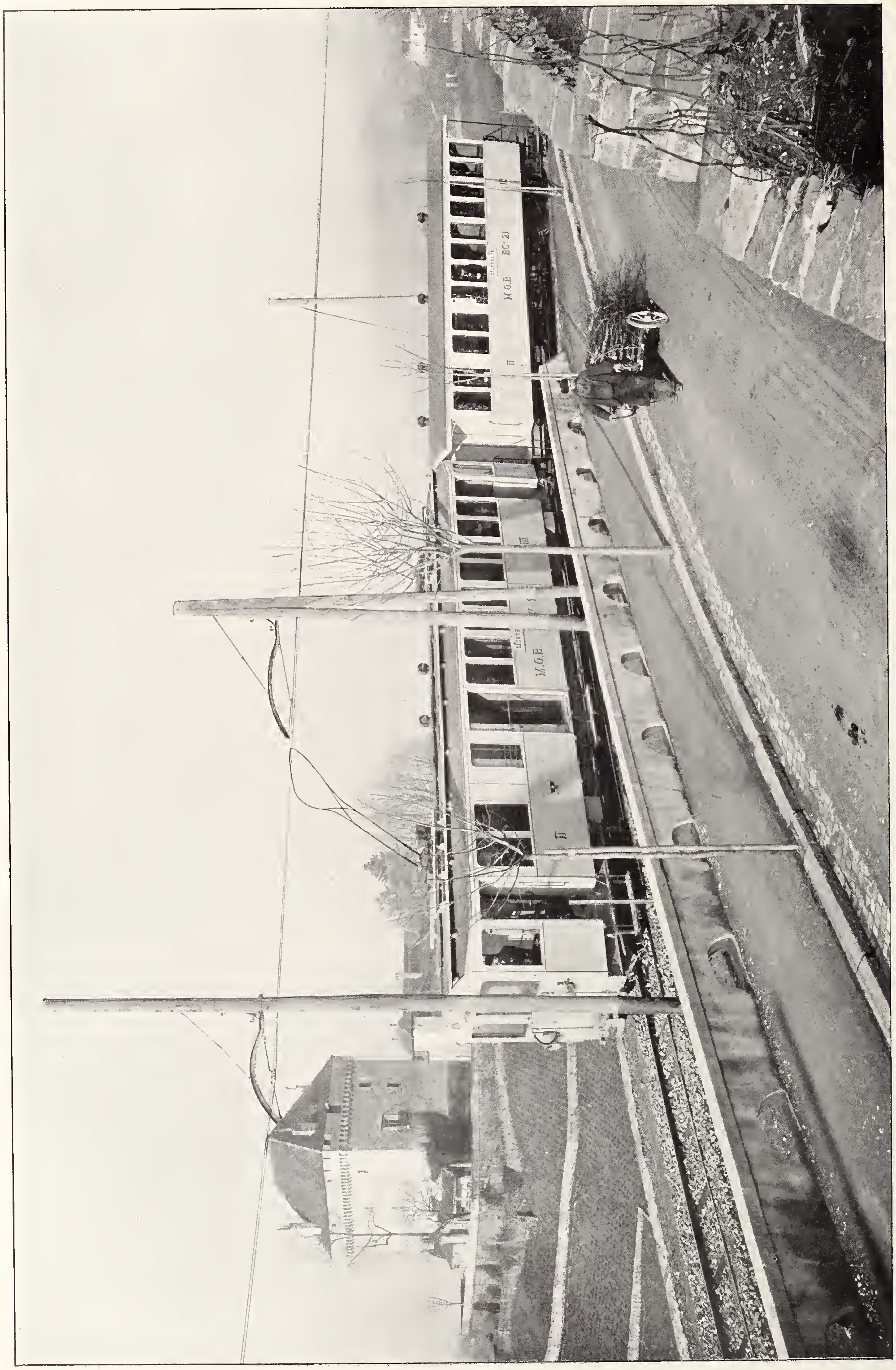
On the Continent of Europe, on the other hand, a sliding bow is employed, and the trolley wheel, as we know it, is symbolical of crudity in practice. A few years ago the bow was made of iron, and considerable pressure was required to make good contact; then an improved bow was brought out, made of brass covered with white metal; and after this came a bow of aluminium with a longitudinal groove at the top filled with fat. This was intended to do away with the scraping noise made by the earlier devices.

The life of a brass bow covered with white metal is said to be about two weeks, while the aluminium bow lasts from six to eight weeks. The maintenance cost of both the types of bow is practically the same, and is given as about 0.026 cent per car-mile. The contact pressure on the wire should be only just sufficient to prevent sparking, and, according to a Dresden law, must not exceed 7.7 pounds, and is usually below it. It has generally been supposed that the bow

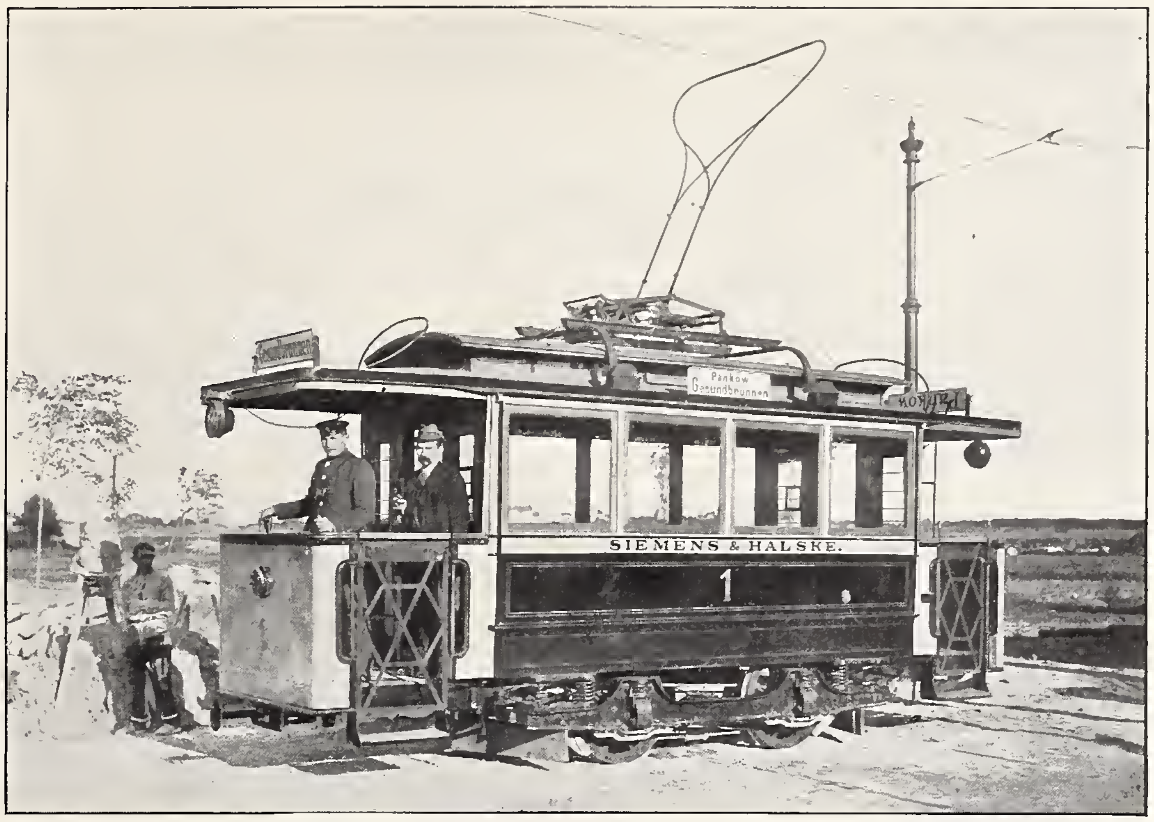


MOTOR AND TRAILER CARS ON THE DOUGLAS & LAXEY COAST ELECTRIC RAILWAY, ISLE OF MAN, BUILT BY MESSRS. MATHER & PLATT, LTD., MANCHESTER, ENGLAND. THE CURRENT COLLECTOR HERE TAKES THE SHAPE OF A LONG ROLLER

THE DEPOT AT MONTREUX, SWITZERLAND, ON THE BERNER OBERLAND BAHN. TWO FORMS OF OVERHEAD CONSTRUCTION FOR TROLLEY WIRES ARE HERE ALSO SHOWN



TROLLEY CARS ON THE BERNER OBERLAND BAHN, SWITZERLAND. THE BOW COLLECTOR IS SIMILAR TO THE GERMAN PATTERN



A TYPICAL GERMAN TROLLEY CAR, BUILT BY MESSRS. SIEMENS & HALSKE, BERLIN, SHOWING THE SLIDING BOW COLLECTOR

contact wears the wire out more rapidly than the roller, but this has been claimed to be erroneous, as the bow is said to wear a flat on the wire at the bottom only, while the roller wears it at the sides also, especialy on curves.

Wireless Telegraphy for the Navy

ADMIRAL MANNEY, chief of the Naval Equipment Bureau, recently entered into agreement with Abraham White, president of the American De Forest Wireless Telegraph Company, for the acquisition by the navy of five of the longest wireless telegraph circuits in the world up to this date, two of them being more than 1000 miles in length.

The navy has felt keenly the necessity of a wireless connection between its naval bases at Guantanamo, Culebra and Key West, realizing that in the event of hostility with a foreign power the existing cable system would be the first point of attack. The necessity of protecting the canal zone has enlarged the problem of finding a secondary means for communication, and the general board has learned a lesson from the isolation of Port Arthur in the present war.

Therefore, some time ago, the equipment bureau began a series of competitive tests under the immediate direction of Lieutenant Commander Jayne, and the result was the arrangement to-day between Admiral Manney and Mr. White to sign a contract for the supply to the Government of wireless instruments guaranteed to maintain trustworthy service on these circuits:—Key West to Panama, 1000 miles; Porto Rico to Key West, 1000 miles; South Cuban coast to Panama, 720 miles; Pensacola to Key West, 450 miles; South Cuba to Porto Rico, 600 miles.

The service proposed is exceptional, in that the wireless currents must traverse not only the ocean, but leap over islands, such as Cuba and Hayti, and in the latter case, and perhaps in others, run a risk of crossing currents set up by apparatus on islands not a part of the United States. The contracting company assumes full responsibility for the working of the system in such cases.

On its part the Government agrees to operate in harmony with such stations and vessels as now use the De Forest system, and this is said to extend to Panama. The Government's instruments will be attuned to harmonize with those of the company to prevent interference. The navy will have the company's key, so the two may work interchangeably without the possibility of their messages being picked up or stolen, or suppressed by vessels or stations equipped with other kinds of apparatus. The enormous value of wireless telegraphy in naval operations, as revealed by Admiral Toga's last exploit off Port Arthur, hastened the action of the Navy Department in closing this contract.

The introduction of electric traction on the Tranvia Rural, city of Buenos Ayres, is contemplated.

A New Use for the Telephone

A Cleveland man, says "The American Telephone Journal," has instituted a new business enterprise, which opens up new fields for the development of the telephone industry as applied to every-day business. The system is called the Telagirl system, and has been evolved for the saving of time and expense to business men.

The idea of the whole thing is to take charge of the stenographic work of various offices throughout the company's headquarters, which maintains a staff of efficient stenographers. Telephones are installed without expense to the subscriber, connecting him with the company's headquarters, which he can reach at any time. He is at once connected with a stenographer, who takes his dictation either by notes or on the typewriter as preferred, using his personal stationery, which is of course kept on file.

The finished work is then enclosed without folding in a large envelope, sealed and delivered at once by prompt messenger service. The monthly statements rendered to clients of the company are of particular value, as they are itemized in every detail, thus forming a valuable reference index of correspondence to the business man. The most complete privacy is secured, each stenographer having a small room of her own so that messages can be repeated back to the client without being overheard by others.

Copper Production of the World

Henry R. Merton & Co., of London, have published a circular giving the world's copper production for 1902 and 1903. Some of the figures are official and others are very close estimates; those for the United States are taken from "The Engineering and Mining Journal." The quantities are expressed in tons of 2240 pounds:

	1902. Tons.	1903. Tons.
Africa: Cape Colony	4,450	5,230
Asia:		
Japan	29,775	31,360
Australasia	28,640	29,000
Europe:		
Austria	1,015	1,055
Hungary	485	330
England	480	500
Germany	21,605	21,205
Italy	3,370	3,100
Norway	4,565	5,915
Russia	8,675	10,320
Spain and Portugal	49,790	49,740
Sweden	455	455
Turkey	1,100	1,400
South America:		
Argentina	240	135
Bolivia	2,000	2,000
Chile	28,930	30,930
Peru	7,580	7,800
North America:		
Canada	17,485	19,320
Mexico	35,785	45,315
Newfoundland	2,000	2,060
United States	292,870	298,650
Totals	541,295	565,820

Electric Railways in Germany

Costs and Profits

By FRANK H. MASON

From a Recent Consular Report Made by Mr. Mason, as United States Consul-General at Berlin

THE enforced publication of corporate finances and the exhaustive methods by which municipal accounts are kept and made public in Germany, have enabled the Association of Electrical Engineers to collect and formulate some highly interesting statistics on the financial results which have followed the change from horse to electrical traction in street railways in Germany. Although this transformation began later there than in Belgium and the United States, it was made with such promptness and energy that within a period of four or five years the horse car practically disappeared from Germany and was replaced by electrical tramway systems, which traverse all the cities and larger towns and connect each of them with practically every village and hamlet in a large and constantly extending radius.

These systems have now been in operation long enough to supply some definite data as to the profits of such enterprises under existing conditions in Germany, which, measured by average street railway dividends and the market values of their shares, have been in general somewhat disappointing. The net fact, which has been known to investors for some time, and which these newly formulated statistics confirm and explain, is that electric street-car lines, while serving the public infinitely better than any other method of city and suburban transportation yet devised, have proved in many, if not most, cases less lucrative to shareholders than the horse-car lines which they replaced.

There are several tangible reasons for this, some of which are more or less peculiar to Germany. Among these may be cited the fact that most German municipalities refused at the outset to permit overhead conductors to be used in important or centrally located streets, and the companies were therefore forced to use a costly type of car which would take its current in the suburban streets from an overhead wire carrying a voltage sufficient to charge at the same time storage batteries of sufficient capacity to run the car through the central districts where the trolley wire was forbidden. These storage batteries were heavy and expensive, they deteriorated steadily and were difficult to keep in order, and when the snow and ice of winter encumbered the tracks they failed so utterly in Berlin, Hanover and other cities, that thousands of cars equipped with them had to be thrown out and their storage batteries removed. It was only at this heavy cost that the overhead trolley wire secured admission to the central districts of several German cities, and there are even yet in Berlin and elsewhere long stretches on important avenues where it is tabooed, and underground conductors are insisted upon as indispensable.

A second important fact in this connection is that German municipalities are very exacting with tramway companies in respect to rates of fare, paving and all the other specifications of their franchises. Every step in the process of construction is subject to the inspection and control of the city engineers. Most franchises involve the responsibility of the company of laying and keeping in repair the pavement on all space between the two outer rails, a breadth, in case of double tracks, of 12 to 15 feet or more, and where, as in Berlin, the pavement is asphalt laid on deep foundations of rubble and cement, this becomes a heavy item in the cost of construction and maintenance, for no skill and experience seem able to avert the necessity of frequent upheavals for purposes of repair, in which asphalt and cement have to be cut out with cold chisels driven by sledges—a slow and toilsome operation.

Moreover, there are very few municipalities in Germany where electric current can be generated by any other or cheaper power than that of steam or gas engines, and no form of steam fuel is really cheap in that country. Although a very few of the largest central stations produce electric power as low as $1\frac{1}{4}$ cents per K. W.-hour, in most others the cost averages from $2\frac{1}{4}$ to $3\frac{3}{4}$ cents, and in certain small stations as high as 10 cents per K. W.-hour. Estimated by the ordinary German standard, the power consumption per car varies with grade, curves and other conditions from 450 to 700 watt-hours per car-kilometer, equal (in case of the latter figure) to 1170 watt-hours per car-mile.

Finally, the outlay for track renewal and repair turns out here, as elsewhere, to be unexpectedly heavy. In the days of horse-cars a well-laid track in a city of from 150,000 to 200,000 inhabitants would last from a dozen to fifteen years. Now, with the far heavier and more frequent cars, the rails, especially at curves, wear in much less than half that period until the wheel flanges are found running on the bottom of the groove, so that the track has to be taken up and renewed. Another cause of frequent and expensive repairs lay in the fact that the surface resistance of the copper bonds with which the rail ends were united increased rapidly under certain conditions, until their use was largely superseded by the better system of welding the rail joints by means of electrical heat or thermite.

Still another increased item of expense has been that of labor. The motormen are generally employees of a higher grade than horse-car drivers, and being well organized, they have been able to compel increased wages and to shorten working hours until the net labor cost per car-kilometer is more than 50 per cent. greater than in former years.

To all this is to be added the fact that the rates of fare in most, if not all, German cities are rigidly restricted by the authority granting the concession. In Berlin, for instance, street railway fares anywhere within city limits are restricted to 10 pfennigs (2.38 cents), and for the same sum the passenger may ride on some of the suburban lines any distance up to 7 kilometers (4.34) miles. From the latest published statistics it appears that the average street railway fares paid in eleven

principal German cities during the year 1903, varied from 2.2 cents each at Frankfurt to 2.72 cents at Hamburg, the mean average for Berlin and its suburbs being 2.35 cents, or less than half the usual 5-cent fare that prevails generally in the United States.

To complete the restrictions under which street railways operate in Germany, most of their charters contain clauses providing that from a prescribed date the company shall pay to the municipality a portion of its surplus after disbursing a stipulated percentage as dividends. A typical contract of this kind stipulates that beginning with 1903, the company shall pay to the city 35 per cent. of its surplus remaining after a 6½ per cent. dividend has been paid to stockholders, and 50 per cent. of the surplus after an 8 per cent. dividend. Many charters further provide that after being operated by the companies for a specified term of years the whole installation, tracks, power plant and equipment, shall revert in fee simple to the municipality which has granted to the corporation for a term of years the use of its streets.

The total length of German street railways at the close of 1902 was 1906 miles, of which 346 miles, or about 18 per cent.,were under municipal ownership. Of the latter, 65 miles were leased to individuals, leaving 281 miles of lines operated directly by the municipalities. The four longest municipal lines are at Frankfurt, 26½ miles; Dusseldorf, 25 miles; Munchen, 29 miles, and Koln, 40 miles. It does not appear that fares over these lines are lower, but, on the contrary, that they are rather higher than those charged on similar lines worked by individuals or corporations. In Nurnberg, for example, the principal street railway charged under private management a uniform 10 pfennig (2.38-cent) rate, until the city, in order to complete a zone system, took over the private line and thereupon increased the rate of fare. On the whole, it cannot be said that experience has increased public sentiment in Germany in favor of municipal management of street railways, and several cities — among which is Barmen—which built their own lines, are now considering the plan of leasing them to private companies.

By far the largest and most important corporation of this kind in Germany is the Great Berlin Street Railway Company, which, with its various branches, operates 200 miles of track, of which 144 miles are owned and the remainder controlled by the company. On its own lines the "Grosse Berliner ran last year 40,400,000 car-miles and carried 295,000,000 passengers, whose fares aggregated $7,025,000. The total capital of the company is 100,082,400 marks ($23,819,611); its shares are to-day worth 184, and its 3½ per cent. bonds are quoted at 99.40. This, however, is the status of an exceptionally powerful and ably managed company in a large, level city, and is quite above the average financial condition of street railway companies elsewhere in Germany, most of which have to be satisfied with 4 and 5 per cent. net earnings on their stock.

The Berlin company is at present in litigation with the city over a question which, as it involves the important point whether a municipality may grant franchises to new companies on streets already occupied by another lessee, has a certain pertinent interest in this connection. About two years ago there was opened for traffic the so-called Elevated and Underground Railway, a double-track electric line of the most perfect construction and appointment with two arms or branches running from a central station to points in the eastern and western parts of the city. Trains of three cars run over these branches at intervals of three to five minutes, and at such speed as to traverse a distance of 2½ miles in about ten minutes. The line is very popular and carries an immense and steadily growing traffic, which naturally trenches more or less upon the business of the surface lines which belong to the "Grosse Berliner." In order to reach a still more central and crowded portion of the city the new company asks authority to extend its subterranean main stem from the present terminus at the Potsdamer Railway Station northeastward to a point beyond the river. To this the Great Berlin Company objects, and the municipality has applied to the courts to confirm its authority to disregard the protest and grant the franchise for what would be an important public improvement.

The one all-controlling fact which has enabled street railways in Berlin and other German cities to make head against the exacting requirements of municipalities and the enormous cost of conversion from horse to electric traction, with the increased outlay for labor, workmen's insurance, paving and other expenditures, has been the phenomenal increase in business, particularly in the suburban traffic in all the larger towns, which has come with the increased speed, the greater frequency of service, the better ventilation, space and comfort of electric cars. Whole suburbs have been built up within a few years by the influence of a single well-managed tramway line, which carries a legion of men and women to and from their daily toil in the city more quickly and cheaply than the horse-car could transport them half the same distance. And although the electric street railways of Germany under the conditions above described are but moderately remunerative to shareholders, they hold a high place among the potent influences of modern civilization.

Book News

Practical Laws and Data on the Condensation of Steam in Covered and Bare Pipes

By Charles P. Paulding. Size 6½ x 9½ inches; 102 pages. Published by the D. Van Nostrand Company, New York. Price $2.00.

This book is made up in part of a reprint of two articles, written by Mr. Paulding, which originally appeared in "The Stevens Institute Indicator," and in part of a translation of portions of Peclet's "Treatise on Heat," which relate to the emission and transmission of heat from heated surfaces. In the first part the author analyses the results of recent experiments made on pipe-coverings by Messrs. Barrus, Jacobus, Brill, Norton, and by himself, so far as to determine the rate of conductivity of the various coverings as adapted to Peclet's formula for the radiation of heat. He finds that there is considerable variation in these coefficients, as deduced from the results obtained from the different experimenters, and probably this is only what might be expected in view of variations in quality of material and differences in the methods pursued. Some information can, no doubt, be obtained from these somewhat divergent figures, but it appears to us that any computations of the efficiency of a covering based on the coefficient of conductivity determined in this manner must at best be of uncertain practical value, unless actual experiments have been made of a sample of the covering used.

The author draws some interesting conclusions from his study of the subject regarding the effect of thickness of the covering on its efficiency, and he exhibits the results very clearly by means of curves. He finds, for example, that the first half-inch of thickness reduces the loss of heat from 500 B. T. U. per hour per foot run to

125 B. T. U.; the next half-inch of thickness reduces it from 125 B. T. U. to 80 B. T. U.; the next from 80 B. T. U. to 65 B. T. U.; the next again from 65 B. T. U. to 55 B. T. U., while beyond this it requires one and one-half inches thickness to secure an additional reduction of 15 B. T. U. Other curves are given, showing the effect of different steam pressures on the radiation from the covering and thickness of covering required for a constant loss with different diameters of pipe. This is followed by investigations into the loss of heat from bare steam pipes, in which reference is made to tests of the same experimenters. On the whole, the investigations will be found interesting and valuable to students of the subject, and of considerable value to engineers who care to examine into the matter closely.

The translation of Peclet's work is a valuable addition to the English literature on the subject under consideration.

Maver's Wireless Telegraphy

By Wm. Maver, Jr. Published by the Maver Publishing Company, New York; 216 pages, 123 illustrations. Cloth. Price $2.

This is the first book on wireless telegraphy that gives a comprehensive description of the apparatus, circuits and practical operation of the various wireless systems now in use in all parts of the world. Hitherto the four or five books on this subject in the English language have treated it either from the mathematical or the strictly popular side, and, truth to tell, some of the latter have been, to say the least, disappointing.

In the work before us the avowed object of the author, who is well known as the writer of a standard work of an encyclopædic character on telegraphy and telegraph engineering, is to do for wireless telegraphy what has been done for telegraphy in general, namely, to provide a complete practical handbook on wireless telegraphy. In short, borrowing the language of a contemporary reviewer, Mr. Maver has in this work not traded on his reputation as a writer on telegraphy and other subjects and thrown together a haphazard, catch-penny volume to meet the sensational demand of the hour, but with his usual thoroughness and clear cut style, while giving ample space to theory, has treated the subject soberly and seriously in a highly practical manner.

With such a book at hand it is not too much to say that even a layman may readily obtain a mental grasp of any of the systems and theories described. The section devoted to practical suggestions relative to the alphabets used and the actual manner of signaling by wireless telegraphy, is sufficently clear and full to enable any intelligent ship's officer, lighthouse keeper or other interested person to acquire the ability to operate the apparatus and to transmit and receive messages with comparatively little practice. In view of the rapid application of wireless telegraphy to inter-ship communication, it would seem that this single feature of the work should obtain for it an important place in the library of every ship equipped with wireless outfit.

A chapter on the propagation of electric waves and the electron theory will doubtless prove to be of unusual interest to many readers, as it deals with these usually abstruse subjects in a popular and lucid manner. A judicious and natural allotment of space is made to the different systems described, in the order of their utilization in general practice.

Thus the Marconi system is treated first and at greatest length. The other European systems, like the Lodge-Muirhead, Slaby-Arco and Braun are next considered, after which the systems of the American inventors, De Forest, Fessenden and others are suitably described.

An important feature of this book and one not indicated by the title, is a lengthy chapter on wireless telephony, in which the work thus far accomplished in the wireless transmission of speech is graphically set forth. A chapter is also allotted to a consideration of the coherers, detectors, oscillators, condensers and aerial wires employed in this art. In the closing chapter of the book, which deals with the practical applications and the prospects of wireless telegraphy, there is much that will appeal to the general reader, and especially to the inventor, since the author is impartial in his statement of the facts as he recognizes them.

Radio-Activity

By E. Rutherford. Size, 6 x 9 inches; 400 pages. Published by the Macmillan Company, New York. Price $3.50.

The well-known ability of the author of this volume as a worker in the field of radio-activity, is initially a guarantee of the excellence of this book. The subject naturally opens with a discussion of the radio-active substances, uranium, radium, thorium, polonium and some of their compounds, in which will be found much interesting data concerning these substances. The immediately succeeding chapters are devoted to a consideration of the ionization theory of gases and the methods of measuring the radio-activity of radio-active substances, namely, by the action of the rays on a photographic plate; by the electrical or ionizing action of the rays on the surrounding gas, and by the florescence produced by the rays on a screen of zinc sulphide or similar substance.

The author goes carefully into the details of these methods of measurement, especially the electrical, the description thereof being illustrated by numerous diagrams. In Chapter IV. the nature of the radiations is treated of at length, and in the remaining chapters, the rate of emission of energy, the properties of the radiation, the production of radio-active matter, radio-active emanations, excited radioactivity, radio-active processes and radio-activity of the atmosphere and of ordinary materials, are taken up and dealt with in turn.

We do not doubt that this timely work will be welcomed no less by the general reader than by the specialist, not only as a very valuable addition to the original literature of this subject, but also because it contains within its covers much information that could be obtained elsewhere only by careful gleaning through a widespread number of separate articles in various scientific periodicals. This information the author has elucidated in a pleasing and easily understood manner, for which kindness numerous readers should, and no doubt will, be properly grateful. Seventeen pages of index constitute a valuable guide to the contents of the book.

Friction and Lubrication

A Handbook for Engineers, Mechanics, Superintendents and Managers. By William M. Davis. Published by The Lubrication Publishing Company, Pittsburg, Pa.; 225 pages. Price $2.00.

This book is the work of a practical man, who has been for ten years in a position to make a close study of lubrication on many kinds of engines and machinery. It begins with a statement of Morin's five laws of friction and an elementary explanation of the method of determining the coefficient of friction. Then follows a brief discussion of the friction losses in engines, shafting, etc., and of the power required to operate machine tools. The nature and use of oil as a lubricant and the instruments and methods used in testing oil for purity, viscosity, evaporation and friction, are treated somewhat more fully. Two short chapters are devoted to the subjects of cylinder and valve lubrication and to sight-feed and force-feed lubricators, of which many illustrations are given.

Four brief chapters treat of the lubrication of engine cylinders and valves,

of the groaning of pump and engine valves, of deposits of sticky substances and of deposits in engine cylinders caused by boiler compounds. The lubrication of gas and gasoline engines, air compressors, locomotives, railway and street railway cars, automobiles, marine engines, mining, refrigerating and textile machinery, rolling mill and blast furnace machinery, elevators, pump plungers and flour mill machinery, occupies several very short chapters. Other chapters discuss oiling devices, filters, automatic oiling systems, lubrication of belts and of enclosed crank case engines, grease, bearings and journals of different metals and alloys, treatment of hot bearings, ball and roller bearings, etc.

The book is written in a clear and simple style, and may easily be read by any operating engineer. It contains sixty illustrations and a very complete index. We note a little slip on page 5, where it is stated that one-horse-power exerted in overcoming friction results in the conversion of energy into 43 British thermal units of heat. The words "per minute" should be added. There is also an error in the statement, on page 11, that until within recent years in well-constructed stationary engines the friction often amounted to 15 or 20 per cent. of the total power developed, but that in modern construction the friction horse-power often amounts to only 2 to 3 per cent. The friction loss of a good Corliss mill engine was as low as 10 per cent. forty years ago, and it is not probable that it has ever been reduced to below 8 per cent. of the rated power.

Electrical Engineering Experiments and Tests on Direct-Current Machinery

By George F. Sever. Published by the D. Van Nostrand Co., New York. Size, 8½ x 5½ inches; 64 pages, 22 illustrations. Price $1.

The author, who is the adjunct professor of electric engineering at Columbia University, has given in this little book a considerable amount of useful practical information concerning methods of testing direct-current dynamos and motors. Instructions are also given for making a number of experiments representative of conditions that are likely to be met with in practice, such as the determination of the magnetization or saturation curve of a shunt dynamo; the useful commercial efficiency of a shunt-wound motor by means of the Prony brake, together with suggestions as to the best manner of handling and arranging the testing apparatus, etc. Tabulated blank forms for recording the results of tests and experiments are also given, the idea being to familiarize the student or the non-electrical engineer with approved methods of preparing reports of work done in actual practice. We have no doubt the book will also be found of utility for reference by practicing electrical engineers. The diagrams that accompany the text are plainly drawn. The addition of a table of contents or an index would be an advantage, notwithstanding the limited size of the book.

Modern Wiring Diagrams and Descriptions

By Henry C. Horstmann and Victor H. Tousley. Size, 4½ x 6¼ inches; 157 pages. Published by Frederick J. Drake & Co.

This little book is written for practical men, presumably by practical men, and is intended by the authors to be supplementary to more pretentious works on the subjects of which it treats. It contains numerous diagrams of bell circuits, house, fire and burglar alarm circuits, gas lighting circuits, electric lighting circuits; in fact, it touches upon the majority of such subjects as the ordinary electrical worker is likely to encounter in the usual run of his work. The diagrams are fairly well made and the descriptions of them are generally succinct and clear. It should prove to be a useful reference book for those interested.

Testing of Electro-Magnetic Machinery and other Apparatus

By Bernard Victor Swenson, E. E., M. E., and Budd Frankenfield. Published by the Macmillan Company, New York. Size 6½ x 9½ inches; 420 pages. Price $3.

We have in the work before us a text book of much merit on the testing of direct-current dynamo machinery and apparatus, written by men who have put to proof the methods therein set forth. The book is also in a sense a digest of the methods of many other writers on these subjects, credit being given in the opening pages of the book to no less than sixty-six works and articles on cognate subjects.

The general treatment of the subjects as well as the method of their arrangement, however, are original, and the procedure employed is that which has been followed in the laboratory work of the authors. This book is to be followed by a second volume treating of alternating-current machinery and apparatus. A valuable feature of the present volume, considered as a text book, and one upon which stress is laid, is that the treatment of each experiment is self-contained, this giving the instructor wide scope in the arrangement of his lessons to individual students.

Among the experiments described in the book are the measurement of armatures and fields by fall of potential method; magnetization tests of iron by the ballistic method; starting of shunt and series motors on constant pressure circuits; tests of iron by Ewing bridge; external characteristics of a differential compound dynamo; test of a tractive electromagnet; tests of fuses; tests of a storage cell. In all, ninety-six such experiments are listed. A useful series of tabulated forms for the preparation of reports of shop tests is furnished in an appendix.

While the authors resorted to mathematical analysis in quite a number of instances, this is only done, they explain, for the sake of clearness. The diagrams of circuits and connections are excellent, much better, in fact, than the ordinary. The examples of methods of calculating values are well chosen, and the explanations accompanying such examples are illuminating. In short, excepting some poorly reproduced half tones of photographs of certain apparatus, we have only commendation for this book.

The Outlook for Electrical Engineering in Germany

SOME anxiety is expressed as to how the greatly enlarged electric works in Germany are to be kept in constant and lucrative employment. The near future offers litle prospect for the installation of new central stations, and the demand for electric tramways is very small indeed, as the larger towns have been already provided, and electric traction only pays in towns of more than 40,000 inhabitants. There are at present only nine towns of this size in Germany without electric street railways. Unless considerable saving can be effected in the working of electric tramways only about 150 miles could be laid and worked at a profit during the next ten years, that is to say, about half the mileage operated by the one electric tramway company in Berlin.

The Northern Indiana & Southern Michigan Telephone Company, operating in LaGrange, Ind., with exchanges at Ashley, Lima and other towns, has adopted the plan of giving subscribers daily market and weather reports. A universal call is rung over the line, and all subscribers may listen if they choose. The Lima office has been made an all-night exchange, with a woman operator in charge. The all-night service and weather and market reports are doing much toward increasing the number of subscribers.

THE ELECTRICAL AGE

Volume XXXIII Number 1
$2.50 a year; 25 cents a copy

New York, July, 1904

Entered at the P. O. as 2d-class matter.

ESTABLISHED 1883

Published monthly at 3, 5 and 7 W. 29th Street, New York City.
Telephone No. 1617 and 1618 Madison Square. Private branch exchange connecting all departments. Cable Address—Cassier, New York.

SUBSCRIPTION RATES

The Electrical Age will be sent post free anywhere in the United States and its possessions, Canada and Mexico for $2.50 per year, single copies 25 cents. To Great Britain and all countries embraced in the postal union, $3.75, 15 shillings, 19 francs, 15 marks, or 10 rupees. Send subscriptions to our nearest branch office or agency.

NOTICE TO ADVERTISERS

Insertion of new advertisements or changes of copy cannot be guaranteed for the following issue if received later than the 15th of each month.

LONDON OFFICES

Business Department, 33, Bedford Street. Editorial Department, 22, Henrietta Street. Covent Garden, Strand, W. C.

London Telephone, Post Office, 3807 Central. Private branch exchange. London Cable Address—Revolvable, London.
All remittances to London Office should be crossed London and County Banking Company.

BRANCH OFFICES AND AGENCIES

Subscriptions may be sent to the following branch office or agencies, where they will receive the same careful attention as at the home office in New York:

124, Queen St., Melbourne
359, George St., Sydney
61, Main St., Yokohoma
23, Esplanade Rd., Bombay
33, Loop St., Cape Town
Unter den Linden, 5, Berlin
Nevsky Prospect, St. Petersburg
31, bis rue de Fauburg Montmartre, Paris

General Agents for United States and Canada: The American News Company

Leading Articles

Electricity in Farming. By Hanford C. Johnson ... 1
The Choice of a Steam Plant. By George H. Barrus ... 7
Costly Amateur Electric Engineering. By Egbert P. Watson ... 15
Prices of Electrical Energy in Bulk. By Alton D. Adams ... 16
Notable Electrical Exhibits at the St. Louis Exposition. By Cloyd Marshall ... 18
The Latest Form of Radiophone. By F. G. Fassett ... 23
Notes on European Electrical Practice. By Clayton H. Sharp, Ph.D. ... 25
The Importance of Testing. By Wilson S. Howell ... 27
The Development of the Galvanometer. By J. Wright ... 30
Current-Collecting Devices in Third-Rail Practice. By J. Eugene Wallace ... 34
Electric Railways in Germany. By Frank H. Mason ... 42
Electric Light and Power Enterprises in Great Britain ... 46
Protecting Electric Cables in Manholes ... 46
High-Tension Cable Crossings ... 47
The Telephone in the United States. By Herbert Laws Webb ... 49
Electric Fire Risks. By Herbert S. Wynkoop ... 59

Electric Light and Power Enterprise in Great Britain

IN spite of many legal impediments in the way of electric light and power enterprise in Great Britain, substantial progress has been made along both lines of undertaking. In his recent inaugural address before the British Institute of Electrical Engineers, President Robt. Kaye Gray told that, exclusive of traction motors, in March of last year, lamps and motors equivalent to over 14,000,000 eight-candle-power lamps were connected to the mains of public electricity supply undertakings, London being represented to the extent of about 5,000,000. There were about 300 towns enjoying the advantage of an electricity supply, this number including, with two exceptions, all the towns whose population exceeds 100,000. The exceptions were Tottenham and the Rhondda district, which did not seem anxious to be alongside of their thirty-eight fellows.

It appears that at this period, exclusive of power companies, the public supply stations had motors amounting to 55,000 H. P. connected to their mains. Municipal undertakings own generating plant of a rated capacity of 320,000 kilowatts, and private undertakings are represented by 160,000. In London the companies are proprietors of about 100,000 kilowatts, whereas the public bodies are responsible for approximately 28,000. The pre-eminence of the companies in London is due to the fact that they acted as pioneers and were first in the field. The average rated capacity of a British station appears to be about 1400 kilowatts. It is to be remarked that while in the provinces the average municipal station has a capacity of nearly three times that of a company station, in the metropolis, the ratio is reversed. Again, the average metropolitan company has, approximately, ten times the plant capacity of the average provincial company.

It is interesting to learn further from President Gray's address that present tendencies in Great Britain are decidedly in favor of the direct-current system with a three-wire distribution; the number of direct-current undertakings increased from 139 in 1901 to 214 in 1902 and 260 in 1903. For these three years the alternating-current stations number 67, 68 and 69, respectively. There are now established in Great Britain thirteen two-phase and five three-phase stations, exclusive of power transmission stations. In twenty-nine cases supply is given on two or even more systems. Many of the alternating-current stations have taken up the supply of direct-current, others have added two-phase or three-phase supply to their single-phase service, or have changed over completely to one of these.

The direct-current system appears to be in no immediate danger of suppression, in part owing to the raising of the voltage, and the consequent possible extension of the service area. The number of voltages in use is somewhat confusing, and presents to the Standards Committee a difficult problem to solve. These voltages now amount to about sixteen, and out of 289 examples of pressure nearly one-third are declared at 230, more than one-sixth are given as 220, while voltages of 240, 200 and 100 claim about one-eighth each. There are between fifty and sixty stations which revel in more than one declared pressure. The extent to which the change from one voltage to another has taken place may be judged from the fact that in 234 cases the pressure is upwards of 200 volts; 64 supply current both above and below 200, and there are only 29 whose supply is entirely under 200 volts.

Protecting Electric Cables in Manholes

IT has frequently happened in the past that when one cable in a system of underground conduits has burned out, the fire has spread to many of the other lead-covered cables in the manhole, the heat and flame from the burning insulation and molten lead of the first cable to give way melting the lead of the adjoining cables, the insulation of which added fuel to the flames. On several occasions in the city of New York more than thirty single cables in a manhole have been destroyed and the service has been crippled for hours by the burning out of one cable. To avoid this wholesale damage to the cables, as well as to avoid the loss of revenue due to delays to service, it was proposed by William Maver, Jr., eight or ten years ago, to the electric lighting and power interests, that the import-

ant cables in the manholes be wrapped with asbestos paper, or that they be covered where they pass through the manholes, with a metal that would resist the flames; but the cost of such protection was thought to be prohibitive at that time. Of recent years, however, with the advent of much larger cables, operating at much higher pressures than formerly was the case, these and other forms of protection to the cables against fire in the conduits are now being quite generally adopted. Where asbestos paper is used it is wrapped around the cables in strips in the manholes and for a short distance into the ducts, strips of brass, laid spirally, binding the asbestos to the cables. In other cases the asbestos is further protected by a sheet-iron sleeve. Still another plan is to protect the cables by putting over them vitrified clay piping in half sections, suitably supported. By such precautions a burn-out in one cable is confined to that cable. In the new power house of the Interborough Rapid Transit Company in the city of New York the cables are not as hitherto suspended along the walls or ceiling, but for similar reasons to those just mentioned, multiple ducts are built along the inside walls of the power house into which ducts the large power cables are drawn.

High-Tension Cable Crossings

THE increasing use of higher voltages in electric power transmission has practically quadrupled the economical area of distribution within the past five years. To-day a transmission of 200 miles at 60,000 volts involves no special difficulty in a fairly dry climate, and it is safe to say that such an undertaking could be successfully carried out by the use of standard apparatus from start to finish. In fact, there is no reason why potentials of from eighty to one hundred thousand volts should not be employed to push the transmitting distance up to 300 miles, with proper safeguards. Transformers have been built for potentials of from two to five hundred thousand volts at the secondary terminals, and, although these have not been used commercially, unless it be for insulation tests, it is pretty well determined that the limit of power transmission depends upon the insulator and the line construction rather than upon the transformer. The adoption of these higher voltages very probably means the supporting of each wire of the transmission circuit upon a separate line of poles and the use of insulators of heroic size; but these considerations certainly are not as formidable to the present-day manufacturer as were the problems encountered in the advance a few years ago from ten to thirty thousand volts.

Aside from the main issues of power transmission, however, a serious condition of affairs has arisen from the multiplication or high-voltage circuits everywhere. We refer to the crossing of such power lines with low-potential circuits employed in telephony, telegraphy, trolley service and electric lighting. The standard protective devices are of little avail in dealing with potentials of from 10,000 volts upward. Not only is the fire risk alarming, but the danger to human life is a menace to be considered wherever such a high-tension line becomes entangled with wires leading into buildings, or even into the primaries of out-of-door lighting transformers. Already a few such crossings have occurred, causing fires at localities often many miles apart. Fortunately, few deaths have thus far resulted from this cause, but unless both power and signaling companies realize the gravity of the problem and institute special safeguards to prevent accidental contacts, loss of life is almost certain to result.

Managers of operating companies are, however, beginning to realize the importance of the question, and in many instances have spent considerable money to improve the construction and location of their lines. The Bell telephone interests have taken up the subject with special concern, particularly in the West, where high-potential transmissions are most common. In the wildest regions of the Rocky Mountains there are some admirable examples of safe construction. One telephone company retained an electrical engineer for the special purpose of making an examination of the condidition of its lines throughout a territory of greater area than New England, and others have taken up the matter with the intention of eliminating every possible source of danger from power circuits.

The simplicity of the remedies employed to prevent these high-tension crossings is a strong argument for their adoption. Of course, the most effective way to deal with the situation is to so locate lines that if they are blown down or carried away by landslides they will fall clear of all other circuits whose potentials involve danger. This can often be done, on account of the generally ruling low value of land in the remote regions through which power is transmitted, and if the question is brought before the promoters of new work in an early stage of the developments a compromise of some sort is usually possible.

Many instances occur, however, where high and low-tension lines cannot avoid crossing one another's right of way. In such cases a construction must be adopted which will carry the lines clear of one another by a span so short that if the upper line breaks, the dangling ends will not be long enough to reach the lower line on either side of the span. The greatest safety is obtained by using two or three short spans at each side of the crossing point, so that if the upper line goes down it cannot curl up underneath and strike the lower line from below. Double cross-arms with extra heavy and well-selected poles, amply guyed, complete the construction.

A fair degree of safety may also be secured by interposing a stout wire-grounded screen between the two lines, of sufficient capacity to carry to ground, without burning off, any current which the high-tension circuit is capable of delivering. Still another method, which has found favor in the case of local telephone circuits few in number, is to terminate the signaling line at poles on each side of the high-tension wires, and carry the low-potential wires across the route of the high-voltage circuit by an underground conduit. The trench should be from four to eighteen inches deep, depending upon the high-tension voltage to be avoided. In rocky and mountainous country the use of iron brackets is sometimes better practice than supporting the lines upon wooden poles.

The responsibility for high-tension crossings depends to a considerable degree upon the company which builds the dangerous line; that is, the right of prior location throws the burden of accident prevention upon the company which is a later comer upon the ground. If a power company builds a 50,000-volt line across a telephone toll line's existing location, the power company should be chiefly responsible for the construction, financially and morally, and vice versa. It is usually the case, however, that both companies can assist in the duty of making the crossing as safe as the state of the art permits, and upon their mutual sense of the dangers of the situation and their harmonious action in the interests of safety depends the efficiency of any preventive measures adopted.

These problems cannot be safely neglected by either power or signaling company, and if their importance is universally recognized, the increasing use of high potentials and extension of low-tension circuits will

meet with little disaster through the accidental contact of high and low-voltage lines.

Reversing Nature's Processes

THE reversibility of the physical processes of nature has at various times been the subject of interesting comment. Lord Kevlin, for example, has been credited with saying that all of them, no matter how complex they might appear to the human senses, consist in reality of the motions of invisible molecules, and if, therefore, by some means, all these molecules could, at the same time, be made to move in exactly the opposite direction, and each with the same velocity that it possessed at the moment, all the world would begin, and continue, to move backward; waterfalls would flow up the sides of cliffs; rivers would run upward from the sea; rain would rise; full-blown flowers would shrink into buds, and plants dwindle into seedlings, man himself would become young again, passing from old age to infancy. Just what kind of picture such a topsy-turvy world would present may be seen with a kinetoscope running backwards.

Some observations along this line were made several years ago by Professor Queroult, of Paris, and an account of them was given at the time in a lecture before the French Academy of Science. It appears that during some of the experiments, Prof. Queroult hit upon the idea of turning around photographic records, and also a series of pictures seen through the kinetoscope. Having photographed a plant at regular intervals and shown in the kinetoscope the growth, the development of the stem, leaves, buds, flowers and fruit, the same consequence of photographic pictures reversed was presented to the eyes of the astonished spectators, who wondered at the fruit being turned into flowers, flowers into buds, buds drawing back into themselves and disappearing, the leaves closing, getting smaller and disappearing, the stem getting shorter and shorter, until the earth closed over it.

Reversing even the most ordinary series of pictures affords startling views. A drinker takes up an empty glass and replaces it full upon the table; a smoker sees the stump of a cigar flying at him from the floor, takes it to his mouth and sees the smoke originate in the room, draws it into his mouth and into his cigar, which is usually lengthened and finally replaced in the pocket. A wrestler, who has probably thrown away his garments, is recovered with them by their, so to speak, walking up on him into their places, while he himself performs motions of which one can understand nothing, because these most ordinary motions, performed backward, are rarely seen. A man, for instance, seated at a table before an empty plate, works hard taking bite after bite from his mouth, until the chicken is whole again on the dish before him, and the side dishes also are returned full to their respective places. All these things, however, are, for the present, not likely to find counterparts in the operations of nature.

The Manila Electric Street Railway

WHEN, two years or more ago, the subject of a street railway franchise was taken up by the Philippine Commission in Manila, the newspapers there waged war upon each other for some time, as to whether the company should be required to lay its wires underground or permitted to string them overhead. The controversy was at last decided in favor of the overhead trolley, and the work is now practically all done except stringing the last few miles of feeders and completing the power house.

As a matter of fact, the line would be undoubtedly safer if the conduit system had been adopted, for the native portion of the city is built of the flimsiest possible materials, a kind of palm leaf thatch, which burns like so much dried hay. On the other hand, the great difficulty in the way was the fact that Manila was built in the sixteenth century at the bottom of a huge bog of soft black slime around the river mouth. Centuries, of course, have changed the character of the soil by piling dry dirt upon wet, beside which there are various strata of broken crockery, tiling, iron, and oyster and clam shells. But the mud is still there at the bottom.

When construction work was begun on the Calzada de Aguadas, or Water Drive, along one side of the Walled City, and leading from the business section to the bay, a spur was projected to cross the fosse and moat and enter the Intramuros, or Walled City. Then the trouble began, for the mud proved so soft that nothing would stay where it was put.

It is perhaps for this same reason, and because of the torrential rains during the summer, that the railway company will have difficulty in keeping to its contract in the matter of road-repair, the contract stating that the company will keep the road in shape for 3 feet on either side of its tracks, which means practically the whole roadway. The soil, though partly volcanic and partly alluvial, is of so loose and spongy a character that it is readily washed away, and in the better paved streets of the business section, in Binondo, for instance, the cobbles rarely ever show a trace of mud or sand even, and when the rains come, the cracks between them are so wide and deep that one may look down and see where the stones are in actual contact with each other, there being in very few cases any earth beneath them or in any crevices. This gives the street a peculiarly bare and uncomfortably clean appearance.

In its power house the company has another problem. There being no competent men on the spot except the constructing engineers sent out from Australia and India to build the line and make the surveys, the plans for the building were drawn in the home office and sent out to be approved. After they had been accepted it was found that the soil of the Isla de Convaléncia, a little islet in the Pasig River within the city limits, where the power station was to be constructed, was so soft and miry that it would be necessary to drive piles down about 30 feet or more to get a foundation. Specially prepared piles were used, so tarred and coated and treated as to keep out both the ants and teredos and prevent the rotting effect of the boggy ground in which they were planted. As matters stand now, everything will be well, unless some particularly vigorous earthquake tumbles the building off the piles and drops it into the river.

Electric Railways in Canada Acquired by Steam Roads

IT is reported that the Grand Trunk Railroad has purchased the Hamilton, Grimsby & Beamsville Electric Railway, and that the Canadian Pacific Railroad has acquired the Niagara, St. Catharines & Toronto Railway. The Hamilton, Grimsby & Beamsville line is 23 miles long and has been doing a large freight business. The Niagara, St. Catharines & Toronto road has been converted from a steam road and possesses some valuable features. The line extends for the greater part over a private right of way and has freight connections with several steam roads. Fifty freight sidings are built into as many manufacturing plants.

The Association of Edison Illuminating Companies will hold its next meeting at New Castle, N. H., on August 30 and 31 and September 1.

The Telephone in the United States

By HERBERT LAWS WEBB

Mr. Webb, in this article, which is reprinted from the July number of "Cassier's Magazine," writes entirely from the standpoint of a British observer who knows a good thing when he sees it. But, while his remarks thus are intended as educational for the British reader primarily,— to give him a measure of the conveniences and excellences of the telephone system in America as compared with the shortcomings of that of Great Britain,— they will prove no less interesting to American readers also. Mr. Webb, though now in England, was closely identified with telephone service in this country for a long time, and knows his subject well. The illustrations, for special use here, were supplied by the New York Telephone Company.—The Editor.

THE United States is the home of the telephone, and certainly the telephone has prospered luxuriantly in the country of its origin. There are many characteristics which distinguish an American from an English city, some of them pleasing, others not; but none is so striking to the observer interested in modern methods as the extraordinarily general use of the telephone. You see telephones literally everywhere. On the office desk the telephone instrument is as regular a part of the equipment as the inkstand. In your hotel you find a telephone in your room, from which you can talk not only all over the city, but all over the country. In the street you are never out of sight of a sign informing you that there is a public telephone within. In your friends' houses the telephone is available upstairs and downstairs, it finds a place in my lady's boudoir as well as in the hall or library.

Every good-class shop has the telephone service, and most of the larger establishments have elaborate exchange installations with a telephone in every department, so that customers can talk directly to the particular branch with which they have business. The convenient public telephone station is to be found wherever a public telephone is likely to be wanted—in the principal railway stations, in hotels, restaurants and theatre lobbies, in all the large shops—or "department stores," as they are called—and in very many small ones much used by the general public, such as tobacconists and chemists; in fact, except in a church, one is never out of sight of the ubiquitous telephone in an American city. The casual or general public use of the telephone is catered to so completely that in many restaurants connecting points are provided at different parts of the room to which a portable telephone set may be joined in a moment, enabling customers to telephone messages between courses.

Comparisons have a bad name, and figures have no particular meaning to many people. One comparison drawn during a recent tour through part of the United States, devoted principally to a study of the telephonic conditions, made a strong impression as illustrating very forcibly the great difference in the development of the telephone in Great Britain and in America. In Great Britain there were in service at the end of 1903, in round figures, some 300,000 telephones. In America the first four cities visited had telephones in service as follows:—

New York and suburbs	130,900
Brooklyn	65,000
Boston	54,000
Chicago	76,000
Total	325,006

Here we have four cities, with an aggregate population less than that of Greater London, using a somewhat greater number of telephones than the whole of Great Britain and Ireland.

An array of statistics might be produced to illustrate the enormous development attained in telephone work in the United States, and still the illustration would be less striking, perhaps, than that afforded by the contrast just cited. What is even more remarkable than the pitch of progress already reached is that there is in sight no apparent slackening in the rate of development.

The American Telephone and Telegraph Company and the companies allied with it, which operate in the various States all over the Union, have invested new capital in the upbuilding of the telephone system at the rate of about forty million dollars a year for several years past, and the capital expenditure on new works is expected to reach the imposing sum of nearly fifty millions of dollars during the current year. That means that the American companies are spending on increased facilities during a single year nearly as much as the whole amount of capital invested in the telephone system of Great Britain. As the president of the American Telephone Company said in a recent annual report, the demand for telephonic facilities in all parts of the United States is greater than the supply.

There are several reasons for this prodigious development of the telephone service in the United States—a development which promises to make the use of the telephone in that favored country practically universal within a very few years—but foremost among them all is the fact that there is no government monopoly in telegraphs in America. The telephone there has consequently escaped the blight of official interference which has restricted its development in every European country. In the United States, the Federal Government has wisely left the conduct of telegraph and telephone communication to private enterprise, and the results have amply justified its policy of non-interference. There has been absolute free trade in telephony, and the telephone companies have been enabled to build up their business on the broad lines of supplying a public demand in the most efficacious manner. They operate under the general telegraph law, which regulates the building of telegraph lines along the public highways, and under their individual charters granted by the States in which they are incorporated; they are subject to the codes of regulations affecting the construction of electric wires adopted by the various municipalities, and, in some cases, to special telephone "franchises," or charters, granted by the municipalities, and they are subject to State and local taxation. But otherwise they are entirely free from government interference and regulations; the life of the business is unlimited, and all questions relating to the rates, the service and the running of wires lie between the companies and the public. The rapid and effective development described above —a development attained nowhere in Europe under the régime of government control—is proof positive that these questions give rise to little friction.

The quality of the telephone service in American cities, as a general rule, is excellent. The answer to a call is quick and the work of completing the desired connection is rapidly and accurately performed. In the larger cities the wires are almost en-

A TELEPHONE OPERATORS' INSTRUCTION SCHOOL

tirely underground; in fact, in New York the greater proportion of the distributing wires are carried directly underground into the subscribers' premises; from this method of construction there results a system that is proof against interruption due to extremes of weather. Even a great conflagration can cause only a local interruption in the particular area affected by the fire. Consequently, a service is produced which, beside being extremely prompt, can be depended upon to be always in working order. When a telephone service of this character is so largely developed that it is used by a very considerable proportion of the community—in New York there is, roughly speaking, one telephone to every five adult inhabitants—it can readily be imagined how enormously valuable a piece of the machinery of life it becomes, how great a factor in both business and social affairs.

So far for the results. While a description of the means by which these results are achieved must necessarily deal somewhat with the technicalities of the telephone business, yet even the non-technical reader can hardly fail to be interested by some account of the machinery of a modern city telephone system and of the business methods by which that system is made available to such an enormous number of users. The American telephone companies have pursued a policy which is distinguished by two main features; first, to bring the service to as high a pitch of perfection as possible, and second, by means of educating the public in the use of the service and by making rates calculated to appeal to all classes of the community, to create a demand for the service so widespread as to be practically universal.

In pursuance of the technical branch of this policy there has been evolved, after nearly two decades of invention and experiment, a method of working the telephone service which is largely automatic. The calling signal is displayed at the exchange by the simple action of lifting the telephone from the hook at the subscriber's station; there is no crank to turn or button to press. Conversely, the replacement of the telephone on its rest at the end of the conversation automatically displays at the exchange the signal to disconnect. Thus, the operation of the service from the subscriber's end of the system is reduced to the simplest possible terms, the necessary acts of taking the telephone from its rest for use and of returning it to its proper place after use, automatically giving the signals to the exchange, which in the older systems of working required the manipulation of buttons or cranks and more or less demand on the memory of subscribers.

This modern system of telephone exchange working is known as the "common battery" system, the underlying principle of the method being that all power—for operating the various signals at the exchanges as well as for energizing the telephone transmitters at the subscribers' stations—is supplied from a common source, a battery of storage cells situated at the exchange. The adoption of a central supply of current does away with batteries and hand dynamos at the subscribers' stations, and, therefore, materially simplifies the apparatus required in each telephone set, resulting in a corresponding simplification of the work of maintaining those sets. But when the working of the common battery system is followed through the exchanges it is seen that from the main feature of this highly ingenious system—the centralization of the supply of power at the exchange—there flow many advantages in the working of the service.

The subscribers' signals for calling and disconnection are, as we have said, given automatically by the necessary acts of taking down and replacing the telephone. At the exchange these signals are conveyed by means of miniature incandescent lamps. This form of signal has several advantages over the indicator shutter formerly used; it is more compact, it is silent and it furnishes a signal that is more assertive than an electro-chemical device. The lamp signal, by reason of its compactness, can be associated immediately with the switch to which it corresponds, which was not possible with the electro-mechanical indicator. This increases the accuracy and speed of the operating.

The earlier forms of electro-mechanical indicators were restored to their normal position by hand, an operation many times repeated during the day, involving much labor to the operators. Later, an indicator was invented which was automatically reset when the operator inserted her plug in answer to a call; but this device had the disadvantage of occupying more space in the switchboard than the manually restored indicator. The lamp signal solves both the space and the labor difficulty, as it occupies an extremely small space—the telephone lamp is about three-eighths of an inch in diameter—and is automatically extinguished when the operator inserts her plug in answer to a call.

As most telephone users know, connection between two subscribers' lines is made at the exchange by means of a pair of flexible conductors terminating in plugs which engage with the switches to which the lines are connected in the switchboard. One of the greatest difficulties in operating a telephone exchange is the proper supervision of connections which are established, the supervision in this case being aimed at preventing two lines being left connected a moment longer than is nesessary. In all the older methods of working it is necessary for the subscriber to perform some definite act—other than the replacement of the telephone on its rest—in order to give the exchange the signal to disconnect; a crank has to be turned or a button to be pressed, or even a button pressed and an order spoken to the exchange. Many subscribers forget to turn the crank or press the button, and the operators consequently have to watch the cords in order to insure that the lines shall not remain connected and (therefore, "engaged") longer than is necessary.

In the common battery system the supervision is automatic. Associated with each of the cords by which the connection is established is a lamp signal, set in the shelf by which the cords and plugs are supported; as long as the two lines connected are in use these lamps remain inert, but when the two telephones are replaced by the subscribers the two lamps glow and the operator, thus positively assured that the conversation is finished, extracts the two plugs from the switchboard, so both freeing the two lines connected and automatically extinguishing the two "supervisory" lamps. If at any time only one lamp glows, the operator knows that the subscriber corresponding to the other lamp is "holding the line," and she does not interfere; the lighting of the two lamps together is the signal for disconnection.

It will be seen that by this ingenious device the operator is constantly and positively informed of the state of affairs on any two lines that she has connected; she has not to "listen in" or to enquire to guard against the mistakes of forgetfulness of the subscriber. She is governed solely by the lamps, and the subscriber gives the disconnection signal by the simple act of replacing his telephone; there is no tax on his attention or memory for the performance of any special act to signify that he has finished talking. As may readily be imagined, this automatic method of working adds largely to the speed and accuracy of the service, the work is simplified both for the operator and for the subscriber, and the required signals are given not only positively, but instantaneously.

A little thought on the question of dealing with the traffic of a telephone exchange shows that the prompt dis-

OPERATORS' DINING ROOM

connection of lines after a conversation is finished is of great importance to the subscribers. The majority of telephone users would agree that the most annoying feature of the use of the telephone service in a large city is the frequency with which the report "engaged" is received in answer to a call. "Engaged" means that the operator has applied an electrical test to the line demanded and received a signal, a characteristic click in her head telephone, which assures her that the line wanted is connected to another. When the signal for disconnection at the end of the conversation is dependent on the memory of the subscriber, it is the invariable experience of telephone operators that many subscribers habitually fail to give that signal. Consequently, on many occasions two lines remain connected for an appreciable time after the precise moment when the connection is no longer required, and as long as they remain connected both of them test "engaged" to every operator who may approach them with a call from another subscriber.

In New York it has been found that whereas under the old method of relying on the subscriber to give the disconnection signal, and on the supervision of the operators to discover when the signal had not been given, there was an average interval of over seventeen seconds between the end of a conversation and the moment when the two lines were disconnected and restored to their normal condition, this interval has been reduced to less than three seconds since the introduction of the common battery system. In telephone work every transaction is measured in seconds; during the busy hours of the day calls rain into a telephone exchange in a perfect torrent, and a gain of fifteen seconds in each transaction is a most important one and cannot but have an appreciable effect in reducing the aggravating "engaged" report.

Although the improved common battery system has been adopted in England by the National Telephone Company and by the Post Office for all their new work, where the large American cities have the advantage is that in practically all of them the improved service is given throughout. The whole system is uniform. In fact, it may be said, broadly speaking, that the method of working the telephone service all over the United States is now uniform. All of the principal cities and many of the smaller ones have changed over to the new system within the past five years. This has involved a prodigious amount of capital expenditure, as it has meant in all cases new subscribers' instruments and new exchange apparatus. But, as is well known, American business men do not shrink from heavy capital expenditure if the result is to be improvement in working and economy in operating expenses.

The rapid march of invention in telephonic working is well illustrated by the history of the New York system. Up to 1888 the New York ex-

change was operated by means of overhead wires, and single, or earthed, circuits. A law was passed about that time forbidding the use of overhead wires, and underground conduits had to be built and metallic circuits adopted, as single wire circuits will not work in underground cables. This involved the reconstruction of all the exchange switchboards. The work of replacing the condemned pole lines by underground cables and of bringing the new exchanges into use occupied two or three years.

Then, early in the nineties, an improved form of switchboard was invented, which was promptly adopted, and several of the principal exchanges were rebuilt with the improved system. Some of the switchboards discarded had been in use only four or five years. In 1898 the common battery system was sufficiently developed to be put into practical service, and late in that year it was adopted in one of the New York exchanges. This method of working was found to possess so many advantages that it was decided to convert the entire New York system, which then consisted of thirteen exchanges and some 30,000 subscribers' stations. This work not only involved the replacing of all the subscribers' instruments by new ones of a different style and the equipment of all the exchanges with new machinery and switchboards, but also the construction of a number of new buildings and extensive changes in the cable plant.

The whole work of rebuilding was completed before the end of 1901, the period of transition being marked by a notable development in the system; from about 30,000 stations in 1898 the number grew to nearly 70,000 at the end of 1901. At the present time in the boroughs of Manhattan and the Bronx, which constitute what is generally known as New York City, over 130,000 telephones are in service.

Similar changes in the mechanical and electrical construction of the telephone service have taken place in most of the other cities in the United States during the past few years. In some, for special local reasons, the work of reconstruction has been delayed and is still in progress; but in most places the whole system is converted, and the latest method of working is in general and uniform use almost all over the country. The American, wherever he goes, finds a uniform style of telephone and a uniform method of operating the service. The precise degree of efficiency of the service in point of speed may vary in different places, as this is to some extent dependent on the personal equation both of the management and of the subscribers; but everywhere it is high.

It is clear that the technical policy of the American telephone companies has been to furnish the best service that could be produced, adopting, to that end, every improvement that invention has devised, and this policy has been carried out so thoroughly that it has entailed in some cases, as

FOR RELAXATION AFTER TRYING BUSINESS HOURS

IN AN OPERATING ROOM OF THE NEW YORK TELEPHONE COMPANY

we have seen, the entire rebuilding of a large city telephone system twice within a decade. While the enormous development that has been attained in the telephone service in the American cities, coupled with the high standard of efficiency maintained, make that service of inestimable value to the community, it must not be imagined that an enterprising technical policy alone has accomplished the phenomenal results achieved.

The telephone companies have not simply provided the machine and sat down and waited for the public to come to them and asked to be allowed to use it. On the contrary, they have pursued also a most "forward" business policy. They have gone out on the highways and byways and said to the public, "Here is a most valuable service, the most useful service of modern times. You should not be without it, for a hundred reasons, and we will supply it to you at a price which you can afford to pay."

In the American papers you will read advertisements headed, "Don't Travel—Telephone!" "The Telephone is the Quickest Messenger." "Telephone Service at your House or Office for —— a month," and so on. The telephone service and its manifold advantages are advertised freely, and the rates are based on a sliding scale, so that the user pays for what he uses.

In the early days of the telephone industry the American telephone companies adopted the system of charging for service, which is still in force, generally speaking, in Europe, *i. e.*, what is known as the "flat" rate—a fixed annual charge per line for unlimited use of the service. In a few instances a departure from this inflexible method was made and a tariff introduced which was based on the amount of use made of the service by the subscriber, thus enabling the small customer to obtain service at a moderate rate and causing the large user to pay in proportion to his use.

But it was not until about ten years ago that the "message rate" tariff began to be widely adopted and scientifically worked out to meet the needs both of the telephone service and of the public. The proper working of the "message rate" tariff demands that there shall be no maximum rate—that each and every telephone message shall be paid for, just as every letter sent through the post must bear its corresponding stamp. If the flat rate is kept in force, the result is that all the large users take the flat rate and only the very small users the message rate. This causes many inconveniences, both of a financial and of a technical nature. The small users, originating little traffic, pay a very small rate, while the large users, having unlimited service, do not pay in proportion to the work they cause, and, by overloading their lines, block the way to incoming calls, so causing other subscribers to receive a bad service.

In some American cities the flat rate has been retained, and the telephone user has the option of paying a fixed annual sum for unlimited service or of paying according to a graduated scale, varying with the number of messages he sends in a year. In New York, however, the flat rate has been entirely abandoned, and a comprehensive tariff of message rates has been worked out, which meets the wants of all classes of the public, from the modest resident or shopkeeper up to the large business establishment, whose telephone cervice can only be adequately handled by a satellite group of lines and stations known as a "private branch exchange."

The flat rate in New York was originally $150 (say £30) a year. When the system was changed from overhead single wire to metallic circuit underground, the rate was raised from $150 to $240 a year for the metallic circuit service, the justification of this increase being the greatly increased cost of building and operating the system. This rate was considered high, and the development of the system was extremely slow during the time it remained in force. To English ears such a rate sounds extremely high, $240 being the equivalent of over £49 But it must be borne in mind in considering all American charges that the purchasing power of money, generally speaking, is considerable lower than it is in Great Britain. Therefore, in comparing American telephone rates with those current in Great Britain, due regard should be given to the difference in conditions between the two countries.

The effect that the message rate tariff has had upon the development of the telephone in New York is strikingly illustrated by contrasting the period during which only flat rates were in vogue with the period during which the message rates have entirely supplanted the flat rate. In 1894 the New York system, after nearly sixteen years' existence, had about 10,000 stations. In the summer of that year the first message rate tariff was tentatively adopted and an active policy of advertising the service and canvassing for subscribers was begun. In a very few years the system was doubled in size, as in 1897 there were over 25,000 stations where in 1894 there had been only 10,000. As experience was gained in the working of the message rates, the tariff was modified in various ways until, as has been said, a thoroughly comprehensive scheme of rates has been evolved which seems to meet all requirements.

During the past few years the annual increase in subscribers has reached prodigious figures—between 25,000 and 30,000 each year—and the total increase in telephones in New York in nine and a half years has been 120,000. So that in less than ten years under message rates twelve times as many telephones have been put in service as were established during sixteen years under the flat rate régime.

The basis of the New York tariff is a minimum annual charge for a certain number of messages, the rate for additional messages being on a sliding scale, so that the price per message decreases as the number of messages used in a year increases. The minimum rate for an individual line, for business purposes, with 600 messages to be sent in a year, is $75 (say £15.10). Additional messages are charged at 8 cents (4d.) each at first, and gradually decrease as the subscriber uses a larger number to 5 cents (2½d.) each. But if the subscriber estimates his annual use in advance and contracts for additional messages by the hundred, he gets them at a lower rate, beginning at 6 cents (3d.) each and running down to 3 cents (1½d.) each.

Should the subscriber not use up all the messages he has contracted for, the company returns or credits, at the end of the contract year, whatever amount has not been earned. The tariff for an individual business line runs up to 4500 messages in a year for $228 (£47), that number of messages, corresponding to an average of fifteen per working day, being considered the maximum outward use which should be made of one line, having due regard to the availability of the line for inward calls and to the great concentration of telephone traffic at certain hours of the day.

Provision is made for the busy establishment requiring a large use of the telephone service, first by a rate of $48 (£8.12) a year for an auxiliary line, affording a double track system, so to speak; and second by a "private branch exchange" tariff which sets forth the rates for lines and stations to be used in groups by those establishments whose telephone traffic is too voluminous to be effectively handled over one or two lines. This branch exchange service has proved in New York and in other American cities to be the most effective cure for the "engaged" trouble. It is universal experience that the subscribers chiefly responsible for "engaged" are those who make very large use of their lines for outward calls, thus

THE WIRE CHIEF'S DESK—FOR TESTING AND LOCATING TROUBLES

blocking the way to the calls which others are trying to make to them.

The obvious remedy is for the very busy subscribers to take more telephonic facilities; but as the blocked inward calls go unperceived by them, it is difficult to pursuade them to do so. The private branch exchange system, which was devised to cope with this evil, consists, as its name implies, of a small telephone exchange system installed on the premises of the subscriber and connected by two or more junction lines to the nearest exchange of the general system. From the branch switchboard, which is served by a trained operator, lines are extended to the various departments in the office or building.

The advantage of this method of supplying the telephone service to a busy concern are many. By means of the extension telephones the service is made available exactly at the points where it is wanted, those who have to use the service much do not have to go to the telephone—it is within reach of the right hand. The operator at the switchboard receives all the incoming calls and directs each one to the telephone of the particular person wanted, acting as a distributor of the inward traffic. She also gets from the extension instruments the orders for all outward calls and works them through the exchange.

With the private branch exchange the telephone traffic of a busy establishment is handled by an expert, well versed in the importance of accuracy and promptness, instead of by an office boy who too often considers accuracy and promptness of no importance whatever. The provision of several lines between the branch switchboard and the main exchange ensures there being sufficient channels of communication to enable the incoming traffic to have a clear way, and so the branch exchange service helps to lessen the "engaged" trouble and enhances the value of the service to the subscriber. A great advantage of this class of service is that the arrangement is extremely flexible; as the subscriber's business grows, more lines and more extension stations can be added and the telephonic facilities thus kept equal to the demands of the telephone traffic. Conversely, of course, should the subscriber's business fall off, the number of lines and stations could be reduced to fit the altered circumstances.

This private branch exchange service has enormously aided the development of the telephone in American cities. It enables the large business houses to get the utmost value out of their telephone service, and in such establishments as hotels and flat buildings it permits of the supply of the service to all guests and tenants at very moderate cost. There are now between three and four thousand branch telephone exchanges in New York, and the number of expert telephone operators in private employ is actually greater than those on the regular operating staff of the telephone company. The number of stations in these branch exchanges runs all the way from five or six up to several hundreds.

At the Waldorf-Astoria Hotel there was recently completed an installation comprising no fewer than 1200 tele-

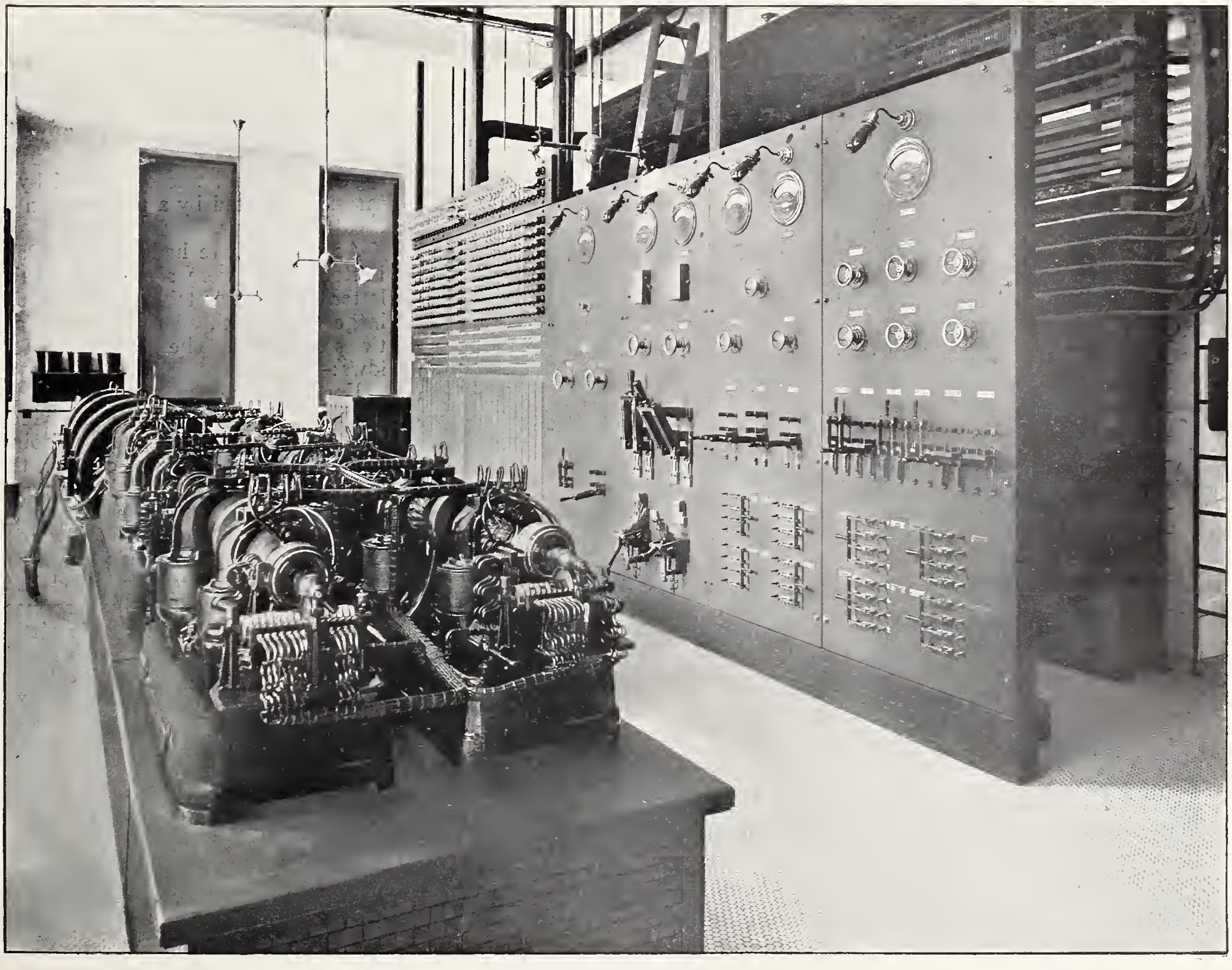
phones; there is a telephone in every room of the hotel and in all the working departments, giving service locally in the hotel, in the city, and anywhere in the United States reached by the vast system of long-distance lines. This is probably by far the largest installation of telephones under one roof in the world. In all the large cities in the United States it is the exception to find a leading hotel where the telephone service is not supplied in this way to every room, and the convenience of this arrangement is something that must be experienced to be fully appreciated, especially as in the American city there is hardly anything you want done or arranged for that cannot be done or arranged for by telephone.

In hotels, too, the branch telephone exchange is of great aid in the service of the hotel proper. If you want anything—and in hotels you are expected to want all sort of things—you do not have to ring for a servant and then give your order; you telephone your order to the office, and it is put in hand with the minimum of delay; thus, you save time and the hotel saves labor. This internal use of the private branch system is valuable in large business establishments as well as in hotels.

The usual method of charging for the private branch exchange service consists of a certain rate for each line and for each station and a wholesale rate for the messages. Thus, in New York the tariff is $36 (£7.4) for each line between the main and the branch exchange and $12 (£2.8) for each extension station, while all messages are charged for at the uniform rate of $3 per hundred—equivalent to 1½d. each. There is also an annual charge for the rental of the branch switchboard, which varies with the size of the switchboard required. In all cases a "message" means an effective call, and all messages are charged to the subscribers who originate them, so that the incoming calls are naturally free to the receiving subscriber.

In hotels, where the management bears all the charges of the upkeep of the installation, the calls are charged to guests at the regular public station rate, which, in most American cities is, for a local call, 10 cents (5d.). As the hotel management buys calls from the telephone company at wholesale rates, the profit on the telephoning done by the guests is generally in excess of the cost to the hotel of the service as a whole. In this way the hotel not only offers a valuable facility to its guests, but it gets a very useful by-product in the interior service and makes a profit into the bargain. The guests of an American hotel use the telephone service very freely. During the first month of working of the Waldorf-Astoria hotel installation in New York the business amounted to over 30,000 calls, exclusive of calls local to the hotel; these latter, being free of all charge, are not recorded.

From the foregoing sketch of the rates and classes of service elaborated by the American telephone companies, it is seen that rates and classes of service have been devised to suit almost every possible user. The



TELEPHONE CURRENT GENERATING AND CONTROLLING APPARATUS. A COMMON BATTERY CENTRAL OFFICE

great merit of the message rate tariff is its extreme flexibility. When it is applied in a thoroughly logical manner, and with no flat rate for the large user to take refuge under, it facilitates not only a very wide development of the telephone, but also a thoroughly satisfactory service. The abolition of the flat rate unlimited line makes it impossible for the large user to block his lines always to inward traffic and to monopolize the junction lines between exchanges, so spoiling the service for other subscribers.

The reciprocal nature of the telephone service is one of its peculiar features that is little appreciated by many telephone users; but since in every telephone connection there are two subscribers concerned, it stands to reason that, unless both use the service in the most effective way, there will result more or less inconvenience at least to one of the two, and generally to both. The average user of the telephone service is apt to regard it from the point of view of his own convenience only, to consider, perhaps not unnaturally, only his own calls, and to ignore the fact that he is part of a system and that the other users depend partly upon him for the quality of service that they receive.

One of the very interesting features of the telephone industry in America is the systematic education of the public in the peculiarities of the telephone service which has been undertaken by the American telephone companies. Reference has already been made to the manner in which the advantages of the service and the rates at which it is supplied are advertised in the daily papers. This newspaper advertising is supplemented by attractively printed and illustrated circulars and booklets which are issued at frequent intervals and distributed wherever it is thought interest in the telephone service can be aroused. In these publications not only are the advantages of the service and its application to all kinds of business and social requirements expounded, but pointed information is given as to the proper use of the service, the effect that one subscriber's use of it has on that of another, the suitability of certain classes of service to certain situations, and so forth.

This propoganda is directed and followed up by a special department of the company whose mission it is to expand and solidify the company's business relations with the public. Thus, a systematic campaign is carried on, first to convince the public of the extreme usefulness of the telephone service and to make widely known the rates at which the service is supplied; next, to induce as many of the public as possible to take the service; then to educate the actual users in the proper use of the service; and finally to persuade the large users to employ the telephonic facilities best suited to give both them and their correspondents the best possible service.

It would be astonishing if exploitation so highly organized and energetically conducted as this did not yield substantial results. The results have been, as already shown, to secure a development of the telephone service which is unapproached in any European country—a development which is being conducted on the soundest lines and shows no signs of abatement.

Perhaps the most striking feature observed during a recent inspection of the telephone conditions in a dozen of the large American cities was the very practical demonstration of confidence in the almost unlimited future expansion of the telephone system. In almost every city large telephone buildings to accommodate substantial additions to the telephone plant were in various stages of construction, and new exchanges, planned on the most generous scale, were either just completed or just about to be. During recent years the annual increase of subscribers in the large cities has been reckoned in thousands, and in the very largest, such as New York, Chicago, Philadelphia and Boston, by the tens of thousands. There is evidently perfect faith that this phenomenal development will be maintained for a long time to come, and that faith is backed in all directions by works of a most substantial description.

The rates charged for telephone service in American cities sound high to British ears, though, as has been said, they must be considered in connection with the local value of money and with the local conditions. It may be said, in passing, that while the wide development of the service proves that Americans generally do not regard the rates as exorbitant, still they are sufficiently high to tempt capital into competition. Competing companies have established telephone systems in various cities, and especially in the smaller towns in the West; but, so far, the original companies seem to maintain their position in the public favor in all the large cities, having much larger systems than the opposition companies.

The logical deduction from the experience of the American telephone companies, however, seems to be that to attain a sound and wide development of the telephone service depends not so much on extremely low rates as on the supply of a thoroughly reliable and efficient service, and on the education of the public in the usefulness and peculiarities of the service. Perhaps a fairer statement would be that while a first-class service is the prime requisite and systematic education of the public the second, these must be accompanied by a scheme of rates that will be accepted by the public as fair and reasonable and will appeal to the largest possible proportion of the public. The elastic tariff which results from the basing of the rates on the message instead of on the rental of the line and station seems to be the one system of telephone rates which meets these requirements.

A Fraudulent Electric Gambling Device

TO what base uses electricity may be put, even if only in a small way, is illustrated by a device mentioned recently by Mr. George Kirkegaard, of New York City, a model maker, who was engaged to make several parts of the apparatus in question without knowing for what purpose it was to be employed.

The device, as was learned later, was exhibited at a summer resort. It consisted of a large board divided into small squares; on one of the squares was fastened an article, such as a pipe, knife, etc. Each square rested on a hinge, and was controlled by a magnet operated by a push-button in a battery circuit.

As each square had its own push-button, there were about 200 of the latter located on a table in front of the large board with all the different articles exhibited. The game was as follows:—

For a certain coin one could select a push-button, not knowing to which square it was connected. By so doing and making an electrical contact, the corresponding square would fall down on its hinge, and if a prize were fastened to the square, the lucky winner would receive it. All would have been right if fraud had not been introduced; but the operator had a private connection, and at will could let his victim win or lose. The same scheme is practiced in many gambling-house games.

It is reported that Montreal and Toronto capitalists under the leadership of Sir Wm. Van Horne have formed a company with a capitalization of $50,000,000 to secure control of the different street railway systems of Rio Janeiro, Brazil, as well as the lighting facilities of that city. The company has already secured control of the only water power within a convenient distance of the city.

Electric Fire Risks

By HUBERT S. WYNKOOP

IN accordance with that law of compensation under which nature imposes upon us greater responsibilities in return for greater comforts, the employment of electricity for such domestic purposes as heating and lightning gives rise to more numerous chances of danger than accompany the use of gas or oil. This is not to be interpreted to mean that of the agents—whether oil, gas or electricity—one is more dangerous intrinsically than another, but rather that popular unfamiliarity with the latest illuminant leads to a careless handling of electric appliances.

Everyone knows that the filling or the overturning of a lighted oil lamp may start a fire, sometimes preceded by an explosion; similarly, it is a matter of common information that the blowing out of a gas jet conduces to asphyxiation, and that searching for a gas leak with a lighted candle invites an explosion. Therefore, most people refrain from experimenting along these lines, though they may be guilty of outrageous practices in connection with electricity. Comparatively few of the great body of the public are familiar with even the simplest laws of electrical cause and effect; the knowledge of the many is limited to an ability to turn on or off an electric light by means of a key or switch, or to replace a burnt-out lamp with a new one. Evidences of the general ignorance on this subject are everywhere apparent—nails and screws driven into electric light moulding, wires in contact with foreign metallic objects, fuses uncovered, so that molten metal may fly about among easily ignitible material, and conductors so overloaded as to be perceptibly hot.

Some of these evils are due to faulty installation; others, to careless or ignorant handling during service. In the former case, ignorant or unscrupulous persons impose upon the householder, so that his wiring becomes a memorial to the contractor's dishonesty or incompetentcy; in the latter the blame rests solely upon the householder himself.

That the situation is not worse is due primarily to the fire underwriters, who at an early date in electric lighting history, realized the importance of restricting indiscriminate methods of construction, in order that the greatest possible immunity from fires might be secured. In the United States the present rules of the National Board of Fire Underwriters are the standard for electrical construction throughout the country, and work carried out strictly in accordance with their requirements is safe when subjected to reasonable care in subsequent handling. These rules have been developed during the past twenty years, and are still in process of evolution.

The electrical inspection performed by the underwriters, intelligent, honest and painstaking though it be, is not in all respects satisfactory. It rests upon no provision of law, so that, if the construction prove faulty, the insurance companies have no way of compelling the removal of the menace other than by the purely moral methods of increasing the premium or suspending the policy until alterations shall have been made. The inspector concerning himself with fire risks on policy-covered property only, has no power, however, and but little inclination, to trespass upon uninsured premises for purposes of investigation. A fee is usually charged for inspection, and this burden, falling upon the insured, largely augments the premium in the case of a small policy, and in any event encourages concealment of electric alterations or additions, because each notification which results in an inspection entails an additional expense upon the tenant. Furthermore, since the object of the underwriter's inspection is to secure reduced insurance risks, it follows logically that higher premiums permit of taking greater chances, and, consequently, different standards of construction are applied to different householders, according to the rates paid by them.

Several American cities have already instituted systematized electrical inspections and are obtaining satisfactory results from them. Indeed, Chicago has progressed so far that the underwriters themselves, it is stated, have for the past five or six years accepted the city certificates, making few or no inspections themselves; but Chicago is particularly fortunate in the possession of ample and explicit ordinances governing electrical appliances and providing penalties for violation of the rules. Custom differs in various localities as to the charging of fees for inspections; but whichever system be preferred, there can be hardly any doubt that a rigid electrical inspection should be undertaken, under due authority of law, in every community large enough to boast of a sanitary inspector or a fire marshal—if there be in the community any buildings lighted by electricity or served with electric power.

The argument has been frequently advanced that, inasmuch as the underwriters have more at stake than the city authorities, the former should be more worthy of confidence than the latter, and that the most good for the least money may be attained by legalizing the work of the insurance companies. The custom prevailing in a number of localities which requires independent inspections by the city, by the fire underwriters, and frequently by the operating companies as well, involves not only a waste of official energy, but unnecessary annoyance and delay to the occupant of the premises. It seems to the writer that the municipal inspection alone should be required before the appliances are placed in service. A more leisurely investigation of new work, with a view to checking the accuracy of the city inspections, and a periodic survey of old work—for which a large city finds but little opportunity—would then become the proper functions of the electrical bureaus of the underwriters.

While the operation of electrical appliances in buildings is fraught with many dangers if the installation be faulty or the maintenance in unintelligent hands, there is no reason why one should hesitate to avail himself of this modern agent of light, heat and power.

The standard rules governing this subject represent the experience gained through a systematic investigation of fires attributable to electric origin. Unfortunately, there are persons engaged in the wiring business who, either through wilful neglect or through ignorance, depart from the requirements laid down by experience, and it is physicaly impossible for any inspection department to watch work so carefully as to absolutely prevent the existence of defects. In the city

of New York, for example, there are twelve or fifteen hundred electrical contractors, each of whom employs from one to fifty men; and, unless an inspector could be assigned permanently to each of these men, there would remain the possibility of some defects being overlooked. However, the moral effect of the inspection system tends to guarantee the excellence of material and workmanship, for the workman cannot predict what portion of the installation will receive the closest scrutiny, and he is, therefore, not likely to slur any portion of it.

While the last statement holds true generally, there are some exceptions, arising from two reasons. One is the complexity of the rules, which makes some portions of them not easily understood, and which can be removed only by rearrangement. The other reason is a desire on the part of the contractor to undertake the cheapest construction permissible and a tendency to omit those details whose absence is likely to escape detection. To eliminate this evil, provision should be made for the imposition of a penalty to cover intentional neglect of the official requirements or failure to remedy defects within a reasonable time after the service of an appropriate notice upon the negligent person.

The passage of suitable laws providing for the licensing of electrical workers would prove an efficient deterrent to poor work. The plumbing trade is subject to such legal control, and the results attained are eminently satisfactory. A master plumber who knows that his license and his bond are at stake is greatly concerned as to the conscientiousness and ability displayed by his subordinates; and there appears to be no good reason for exempting electrical workmen from similar control.

Aside from the shock attendant upon the passage of electricity through the human body—a contingency rather remote, and one resulting always from abnormal conditions or careless handling—the overheating of ignitable material is the one electrical danger to be apprehended. With electricity such heating may result from various causes. The amount of heat generated by the transmission of electrical energy depends, in general terms, upon the resistance encountered in the conducting medium, the quantity of current flowing and the rapidity of heat radiation. For this reason a poorly constructed joint in wire laid in wooden moulding may, by interposing a high resistance, develop a local heat sufficient to char the woodwork, which eventually bursts into flame; or, a circuit designed for the supply of sixteen candle-power lamps may be called upon to carry the same number of lamps of thirty-two candle-power, thus doubling the flow of current and causing an increased heating effect throughout the entire length of wire; or a wire designed for carrying a certain current when strung on insulators and exposed to the air, may be placed in wooden moulding, at the whim of the tenant, who cannot understand why a larger wire is required for the latter method, because he does not stop to consider the decrease in the rate of heat radiation which results from the change. So, also, the presence of weak or defective insulation may cause a series of infinitesimal leaks from wire to wire, which, added together, assume finite proportions, and may result in adding to a circuit a burden entirely ignored in calculations of wire sizes.

To guard against this overheating the insertion of a "fuse" in the line is usually resorted to. This is a strip of metal of such material and cross-section as to insure its melting—and thus opening the circuit—upon the passage of a current sufficient to barely overheat the wire. The fuse, however, is no protection against the heat developed at bad joints or at points where leakage from one wire to another (or to some other conducting medium) is localized. It prevents an excessive flow merely, not a flow along unauthorized paths or over improper obstructions. And yet heavy copper or iron wire is not infrequently used to replace these fuses, thus defeating the object of the device; and, indeed, cases are on record where the brass-capped fuse plugs were filled solid with lead in order, as the engineer expressed it, "to do away with the only weak part of the system!"

When a fuse "blows," it invariably scatters molten metal, which may communicate a dangerous degree of heat to the material upon which it falls; and yet very many people fail to understand why the inspector requires that the fusing appliance shall be enclosed in a non-combustible case.

The only protection against poor joints lies in the prevention of them. The best protection against local leakage consists in the adoption of a good insulating covering for the wires and of such a method of construction as would permit of the operation of the circuits without leakage if the wires were entirely uncovered, in which case the insulation becomes an efficient factor of safety. The first general suggestion which appears in the rules of the National Board of Fire underwriters of the United States reads as follows:—

"In all electrical work, conductors, however well insulated, should always be treated as bare, to the end that under no conditions existing, or likely to exist, can a grounding or short circuit occur, and so that all leakage from conductor to conductor, or between conductor and ground, may be reduced to a minimum."

"Grounding" is the development of a possible path from one wire to some foreign conducting medium, as, for example, a gas pipe or a metal ceiling; a "short circuit" is a path from one wire to another. Upon this fundamental suggestion by far the greater part of the rules of the above board are based.

An acquaintance of the writer, practiced in the designing of appliances electrical, is fond of characterizing each invention as it comes out as "fool-proof"; and the dominant thought which guides his labors is to so construct his devices that the misuse of them entails more labor than does their proper operation. So it is with the electric wiring rules; they are intended to render the whole construction "fool-proof." Many a provision in them which seems altogether useless at first blush, has been inserted with a view to guarding against the repetition of accidents which have actually happened; and, if we accept the general intent of the rules, we must perforce agree to observe their detailed requirements.

According to "The Telephone Magazine," M. Malcotti, an Italian engineer, resident of Brussels, has invented an instrument which he calls a telecriptograph, and which will produce in print all conversations held over the telephone. He has already secured patents in several European countries and in the United States, where he intends to install his service with the aid of some telephone company. Experiments given in public have demonstrated the wonderful achievement of the young inventor, who claims that his instruments will work without extra wires and apparatus over any ordinary telephone line.

The success of the large hydroelectric power station at Rheinfelden, Germany, has been so great that steps are now being taken to obtain more power from the Rhine at this point. There are three falls of the river near Rheinfelden. The first is the only one that has been used up to this time, yielding 16,800 H.P. The new stations, utilizing the second and third falls, will have an aggregate output of 30,000 H.P., and will supply electricity to the towns of Basle and Rheinfelden.

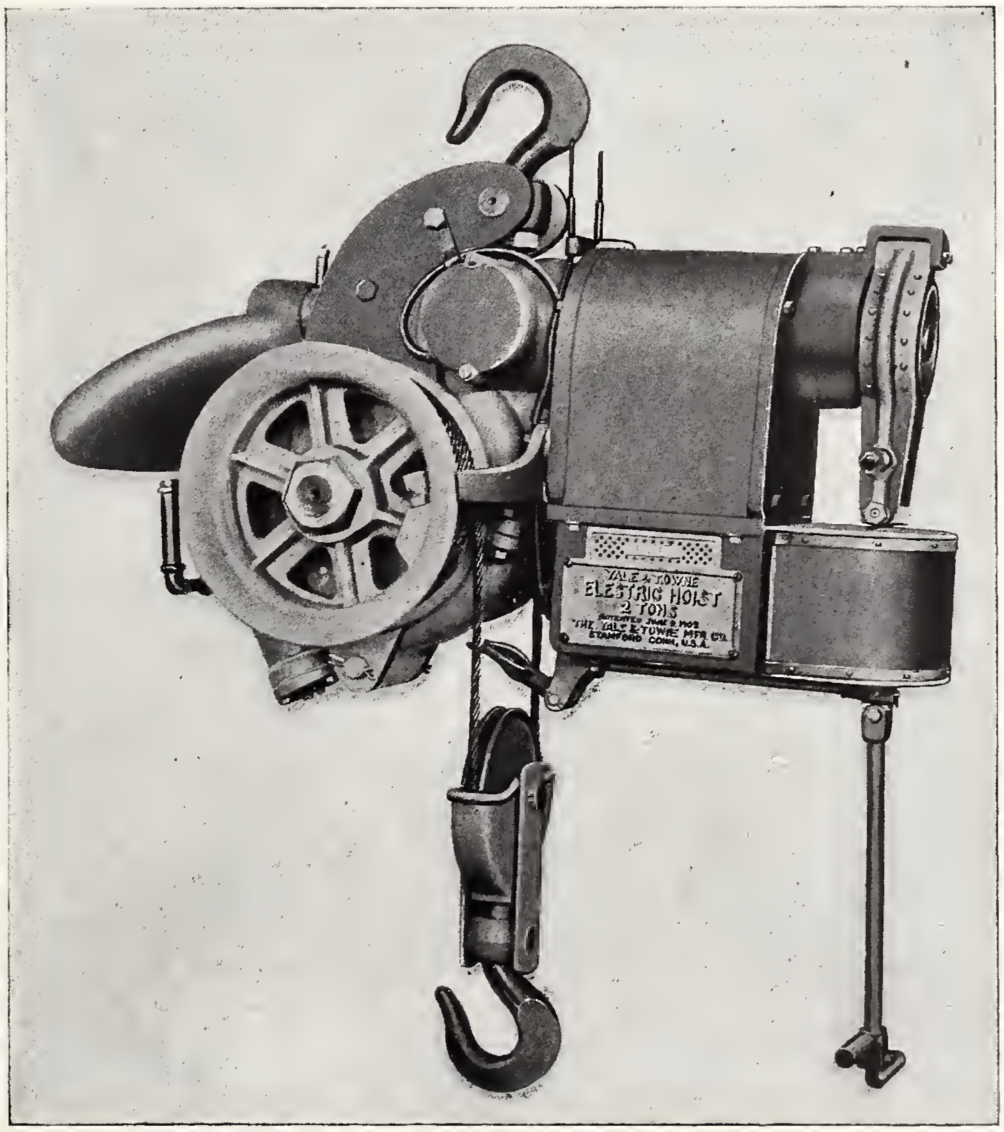
Electrical and Mechanical Progress

An Electric Railroad up Mont Blanc

ACCORDING to "The Scientific American," an electric railroad is to be constructed up Mont Blanc. The cog-wheel system as used on the Jungfrau road is to be adopted. The railroad will start from the village of Les Honches, 3260 feet above sea level, and will climb 11,710 feet to the upper terminus, at a point near the Petits Rochers Rouges. The track will be nearly 11 miles in length, of which more than 6 miles will be in tunnels. The first station will be at the top of the Gros Bechand, 8410 feet high, from which point of vantage a splendid view of the Chamonix Valley is obtained. The second station will be just below the summit of the famous Aiguille du Gouter, at an altitude of 12,600 feet. Thence a hard snow path will lead to the Grand Plateau. The third station will be located in close proximity to the observatory and the refuge hut, at an altitude of 14,300 feet. From here a tunnel will be cut through the northern slope of Mount Blanc proper to the terminus, situated 14,970 feet above the sea. The highest summit, 810 feet above the terminus, will be reached from there on foot or by sledge. The entire train journey will only take two hours.

A Portable Electric Hoist

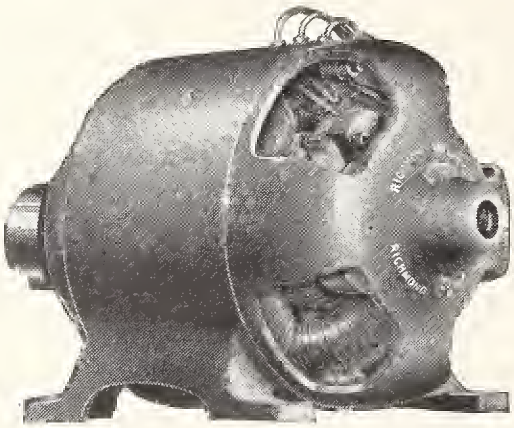
A new electric hoist, built by the Yale & Towne Manufacturing Company, of Stamford, Conn., is shown on this page. It is designed to permit its being moved from one place to another as easily as a chain block. The motor is enclosed in a dust-proof case above the oil-submerged parts of the hoist, the motor shaft bearings preventing the possibility of oil entering the motor. The motor shaft is connected by bevel gears with the worm shaft, the worm engaging with the gear on the drum. All the working parts are enclosed in an oil-tight iron casing which excludes dust and water and insures thorough lubrication.



A NEW ELECTRIC HOIST MADE BY THE YALE & TOWNE MANUFACTURING CO., STAMFORD, CONN.

The load is taken on steel wire hoisting rope wound on grooved drums, which, with the worm wheel, are fastened to the main shaft. The hoist is arranged to balance on the upper hook whether loaded or empty, and to pull in a vertical line through-

out the lift. An automatic cut-off is provided to prevent the load being hoisted too high, and to prevent the load running away even though the



A DIRECT-CURRENT MOTOR FOR MACHINE TOOL DRIVE, MADE BY THE RICHMOND ELECTRIC COMPANY, RICHMOND, VA.

motor or brake should become inoperative. The hoist is provided with an extension rod to allow operation from the floor.

It may be used in any part of the works or yards where current is available, and its use in connection with a hand crane greatly increases the efficiency of the latter. It is made to withstand rough usage in inexperienced hands.

The Widening Use of Electric Welding

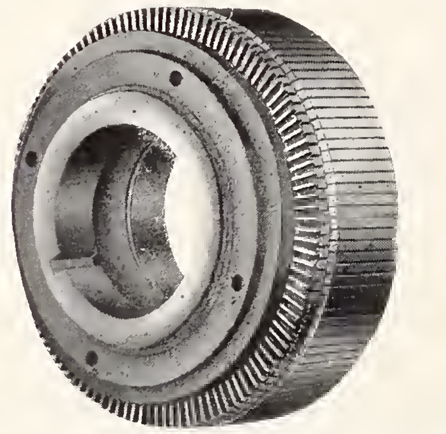
THE electric weld is becoming a more and more important factor in many industries. During recent years, says Elihu Thomson in "Cassier's Magazine," the extension of its application has been steady, and each year has witnessed its entrance into new fields. Sometimes, indeed, new manufactures or new ways of obtaining results have been based upon its use. The electric welds under consideration are the results of that operation of uniting two pieces of metal by what is known as the Thomson process, first brought out by the writer and rendered available in commercial practice a considerable number of years ago. The rapidity, flexibility, cleanliness, neatness, accuracy and economy of the electric process has won for it such an important standing in the arts that many future extensions in its application are assured.

The uniformity of the work, the control of the operation, the extreme localization of the heat to the particular parts to be united, and the fact that the process is not limited to iron and steel, but can deal equally well with other metals, such as copper, brass, bronzes and even lead, are characteristics of the electric welding operation.

In the wagon and carriage industry the process is applied in the production of tires of all sections, axles, hub, spoke and sand bands, fifth wheels, shifting rails, steps, shaft-iron, etc., while it has found a large use in the welding into continuous strips or bands of the wires inclosed in rubber tires for holding them in place. The larger part of the dash-frames used in carriages in the United States are now probably made by electric welding, while iron and steel agricultural wheels are built up, or have their parts united, by electric welds.

To enumerate the many applications to the bicycle industry would be almost to catalogue most of the metal parts of this useful machine. It must be borne in mind, too, that a welding machine, slightly modified, is equally applicable for locally heating parts in electric brazing or hard soldering, for upsetting, and for bending or shaping.

In the wire industry the part played by electric welding is already quite important and becomes steadily more so. Besides the mere simple joining



THE COMMUTATOR OF THE RICHMOND MOTOR

of wires or iron, steel or copper into long lengths, the welding of wire or strip into hoops for barrels, tubs, pails, etc., is supplanting the older forms. Numerous machines are in operation turning out electrically-welded wire fence, much as a loom turns out cloth.

A Motor for Driving Machine Tools

THE motor shown in the annexed illustration is one designed by the Richmond Electric Company, Richmond, Va., for driving machine tools, the motor being connected either by belt or through gears as desired. The great advantage claimed for this motor is that it will not spark or flash over under very heavy overloads—for instance, 5 H. P.; 500-volt motors will not spark under 15 to 20 H. P., with the brushes set in neutral or middle position and not adjusted for direction or rotation. It should thus be possible to fuse this motor at four or five times its normal rating, and, in starting, to throw four or five times the normal current on the motor without the machine showing any signs of distress. It can be reversed under the same conditions.

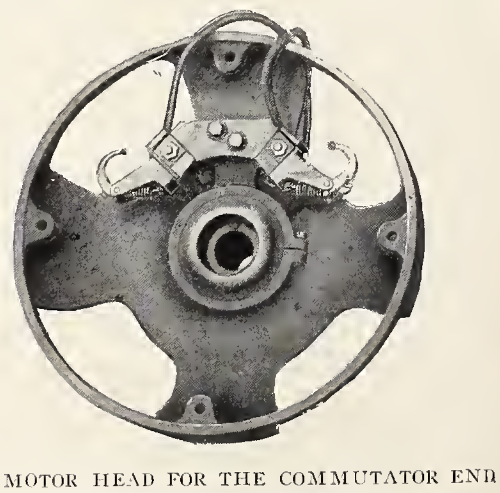
The motor is designed for quick starts, stops and reversals of machine tools, and to be directly geared to them. The amount of time saved by prompt starts, stops and reversals can be appreciated by one familiar with machine work.

In the matter of the small details, the machine has been given careful thought. The railway type of field coil has been used throughout as being durable and capable of standing hard service. The railway method of bringing the leads of the machine out through rubber bushings in the frame has been followed to avoid unreliable porcelain or slate terminal boards, which are so frequently the source of short-circuits and shocks to employees.

The heads are held in by four capscrews, and as the head can, therefore, be turned in the frame, the machines lend themselves either to floor, wall or ceiling use. The poles are set on 45-degree centers, so that for floor, wall or ceiling use there is no bottom field coil to become saturated with any oil or water which may get into the machine.

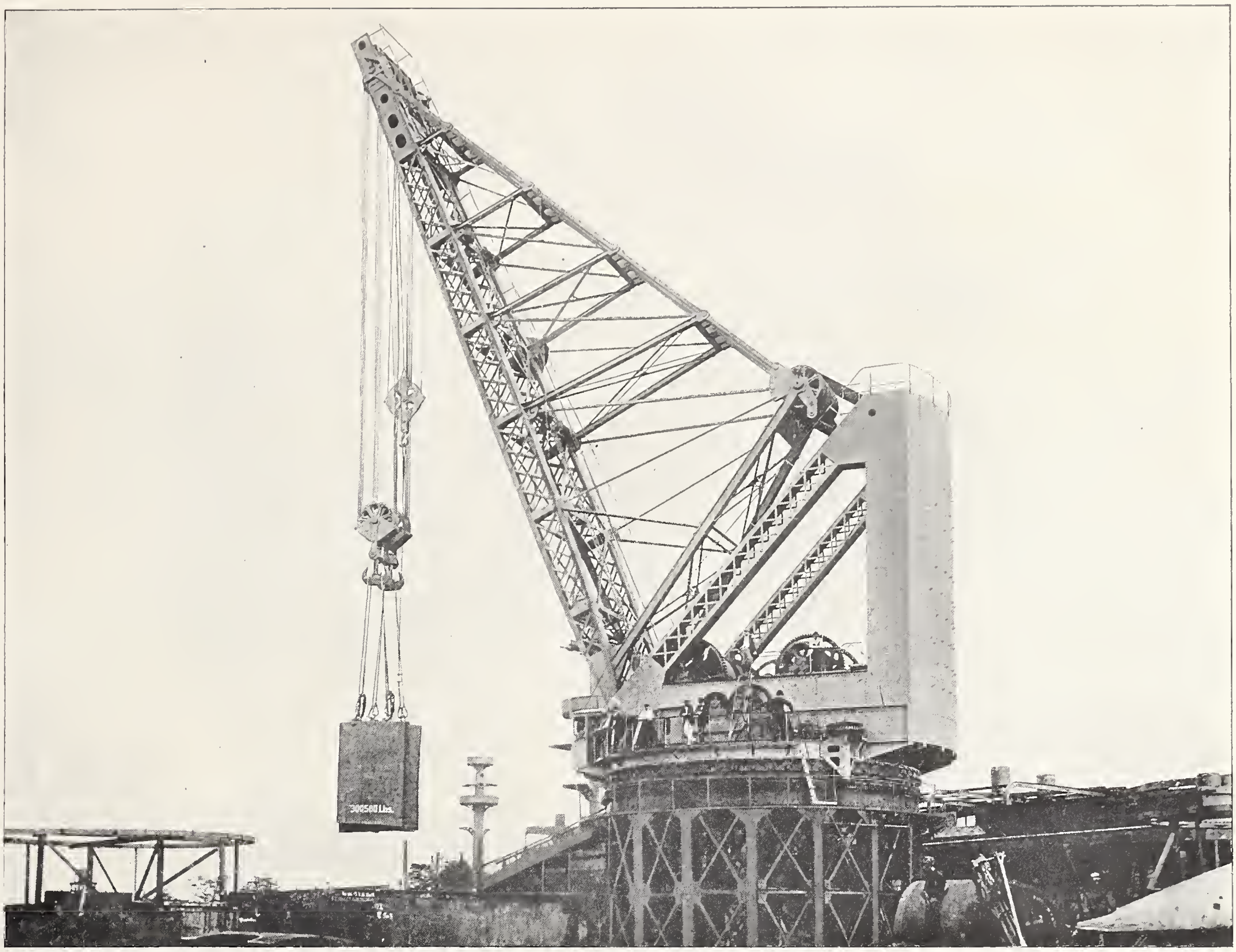
The brushholder ring is provided with stops to prevent the brushes from being carried very far out of the neutral or proper running position. The heads of the armature, comprising in one piece the oil slingers and thrust collars, are shrunk on the armature shaft, thus preventing any possibility of oil creeping along the armature shaft into the commutator and windings.

The commutators are readily removable from the armature without taking any coils off the machine, and the ring lock-in nuts are turned toward the winding, making an addi-



THE MOTOR HEAD FOR THE COMMUTATOR END OF THE RICHMOND MOTOR

tional safeguard against oil from the bearings creeping into the commutator. The commutator segments have considerable depth, allowing long life.



A 150-TON DERRICK, EQUIPPED WITH FIVE 100-H. P. ELECTRIC MOTORS BY THE GENERAL ELECTRIC COMPANY, SCHENECTADY, NEW YORK

The leads from the coils are not soldered in the segment, but the segments are milled a few thousandths of an inch smaller than the width of the leads, and the leads are swedged into the commutator bars, the use of solder or soldering fluids thus being avoided.

A 150-Ton Electrically Operated Derrick

SINCE 1898, the Newport News Shipbuilding & Drydock Company, of Newport News, Va., have employed the electrically operated derrick shown on this page, for the moving of heavy machinery and other material to the ships building at their yards. It was built entirely by the company, except the steel tower, which was furnished and erected by the Berlin Iron Bridge Company, of East Berlin, Conn.

The derrick is built upon a pile foundation, surmounting which is the steel tower, topped by a series of box-girders. To these girders is bolted the cast-steel track carrying the rollers on which the derrick revolves.

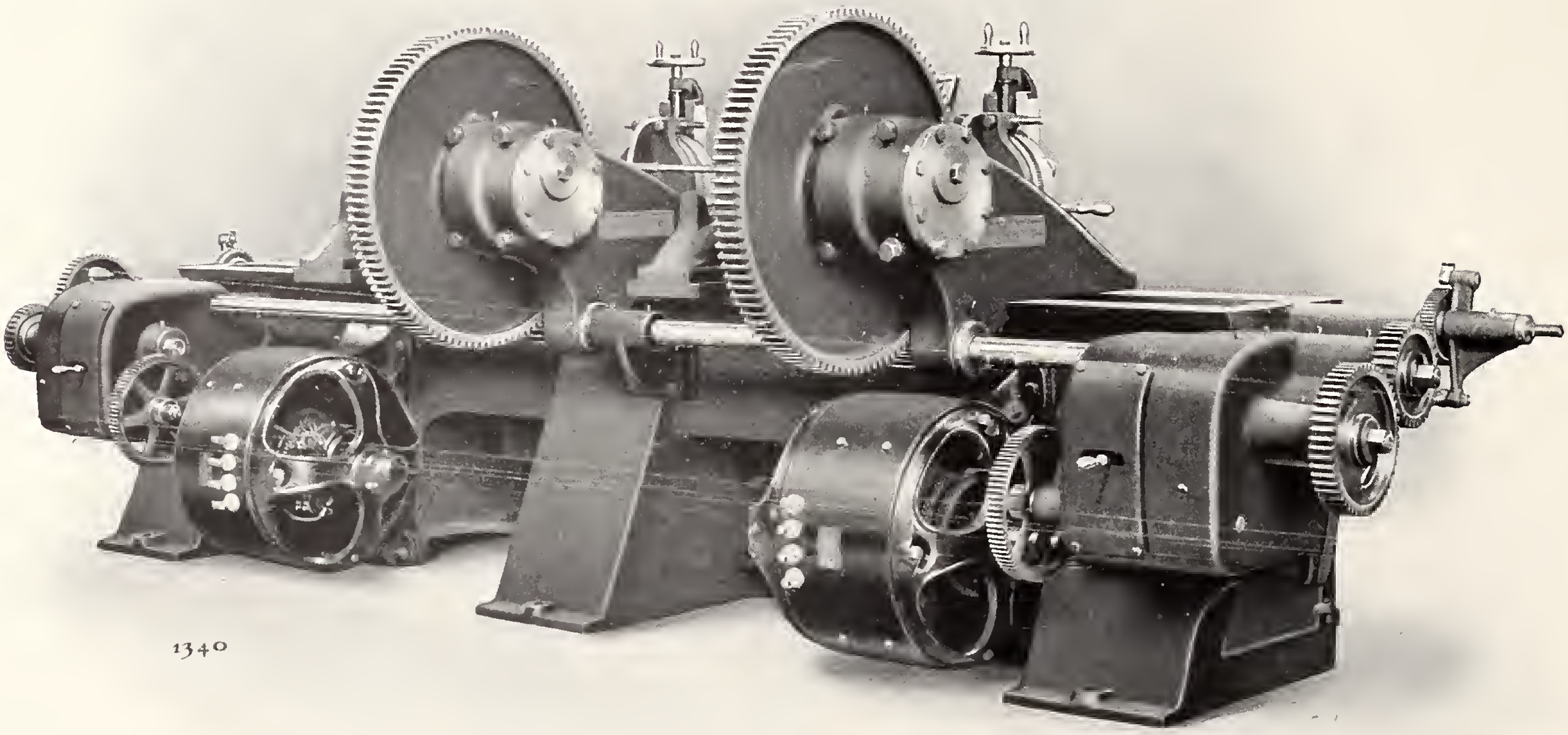
The moving part consists of the housing—a heavily framed structure containing the generating and controlling machinery, operating platform and counterweight, and the jib, which, carried by the housing and controlled by machinery, within the latter, carries the sheaves and blocks for hoisting.

The outer end of the jib can be raised or lowered; in the lower position the hoisting blocks describe a circle 207 feet in diameter, and in the highest position, a circle 88 feet in diameter. The maximum load of 150 tons can be handled only within a ring whose maximum and minimum diameters are 147 feet and 88 feet, respectively; but weight up to 70 tons can be handled throughout the entire range between the 88-foot and 207-foot diameters.

This racking movement of the jib is effected by the following means:—At the inner and upper apex of the jib are twenty-two cast-steel sheaves, each sheave 5 feet in diameter; at the upper apex of the housing are twenty-four similar sheaves. Leading over these two sets of sheaves and carrying the weight of the jib and the load are two $1\frac{1}{4}$-inch steel wire ropes, each rope wound on alternating sheaves, and each end of each rope brought down to separate drums, located below in the housing. These four drums are arranged in pairs, each one of a pair taking opposite ends of the same rope. Each pair of drums is geared to a 100-H. P. series-wound motor.

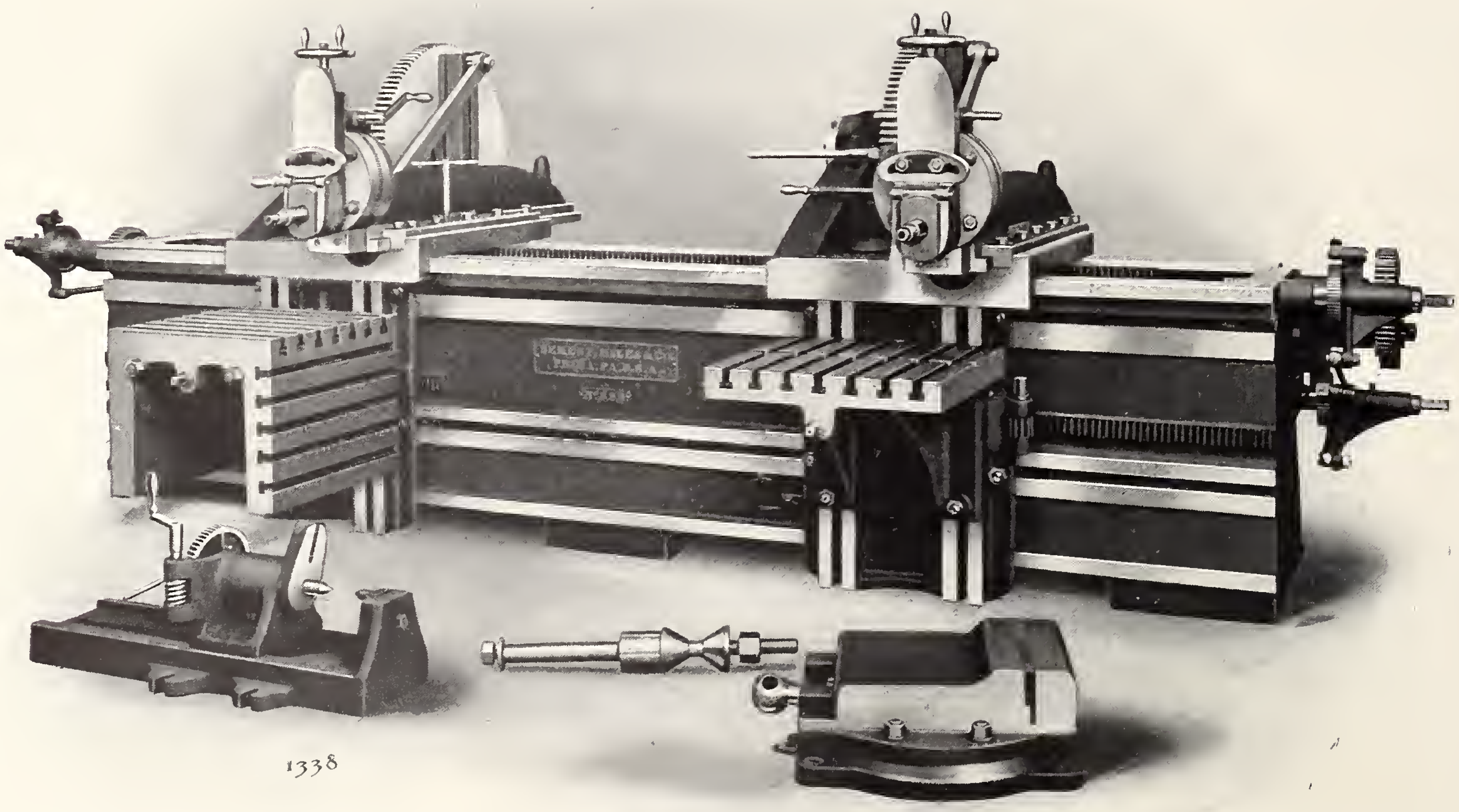
The derrick is revolved by duplicate sets of machinery, each consisting of one 25-H. P. motor, driving, through a double-threaded worm and wheel, a pinion, which engages with a horizontal circular rack on the outside of the tower. The motors are series wound and are controlled by a series-parallel controller.

There are two main hoists, each of 75 tons capacity, and one 20-ton whip for lighter loads. The main hoists are each of twelve parts, with a $1\frac{1}{4}$-inch steel wire rope leading over six sheaves 5 feet in diameter. The drums are of $8\frac{1}{2}$-foot diameter, with 7-inch



1340

A REAR VIEW



1338

A 26-INCH BEMENT DOUBLE SHAPING MACHINE, WITH DOUBLE MOTOR DRIVE, BUILT BY THE NILES-BEMENT-POND COMPANY, NEW YORK

shafts geared to 100-H. P. series-wound motors. These hoists may be coupled together and operated as one hoist of 150 tons capacity. The 20-ton whip is of three parts, with a $1\frac{1}{4}$-inch wire rope leading through a single block and over two sheaves at the outer end of the jib. The drum is 5 feet in diameter and is geared to a 100-H. P. series-wound motor. All of the motors used on the derrick were made by the General Electric

Company, Schenectady, N. Y. Current is transmitted over heavily insulated copper wire to fixed brushes attached at the center and near the top of the steel tower. The brushes bear against circular contact rings, insulated from, but carried on the center casting of the derrick. Near the top of this casting are two more contact rings, which transmit the current to a pair of brushes fixed to the revolving part of the derrick, and from which current is delivered to the motors. The current intensity is usually 220 volts.

A Motor-Driven Double Shaping Machine

MOST electrically driven machine tools confine themselves to the use of only one motor for this operation. In the annexed illustrations, however, a front and a rear view are shown of a 26-inch double shaping machine, driven by two motors through gearing. The machine is built by the Niles - Bement - Pond Company, of New York, and virtually embodies two machines in one, two distinct operations being possible with the double traveling head.

The two $7\frac{1}{2}$-H. P. motors, which may be seen in the rear view, have a speed range, by field control, from 700 to 1400 revolutions per minute. A further speed range is made possible by changing gears, the strokes of the machine by this method varying from four to forty per minute.

The mechanical features of the machine are also worthy of attention. The saddles have a variable power feed along the bed in either direction, as well as a rapid hand movement by rack and pinion.

The cutter bars have a quick-return motion, and may be adjusted for any length or position of stroke. The tool slides are on swivels, and are provided with a vertical power feed, if desired.

Two tables are provided, one with both horizontal and vertical clamping surfaces, and the other with a horizontal clamping surface only. The tables may be adjusted horizontally on the bed by a rack and pinion, and vertically from the front by a screw. The machines are also equipped with a swivel vise, index centers and a cone arbor attachment.

Electrical Progress in Canada

IN a paper recently read before the Canadian Electrical Association at Hamilton, Ont., Mr. George Johnson, Dominion Statistician, said that in the sixty years since the sending of the first telegraph message the use of the telegraph in Canada had so grown that there are now 1764 private and Government cables with a length of 204,527 nautical miles, and on land 5,004,200 miles of line, worth a total estimated outlay of $850,000,000. Over these the daily transmission is 1,400,000 telegrams and 36,000 cables, with an annual total of 478,330,000 land messages and 13,140,000 cables. These figures do not include the press messages for Canada, which are large in proportion. In regard to miles of wire, in proportion to population, Canada greatly exceeds the United States, which would have to add 200,000 miles to be equal.

Regarding electrical propulsion, Mr. Johnson said that Canadian street railways during 1903 carried 167,704,000 passengers, which equals 26 per cent. of the city population, as against 37 per cent. in the United States. In Canada in 1903 there were 46 street railways with 455 miles of track, capitalized to the amount of about $30,000,000 paid-up capital, and $17,000,000 of bonded debt.

Canada now has 815,000 instruments, an increase of 144 per cent. in the last four years. There is one telephone to every 65 persons.

In point of light and power companies, it is stated that Canada in 1903 had 324 establishments employing 1786 hands, with an invested capital of $20,000,000. For the same year the Dominion had 14,780 arc and 1,212,861 incandescent lights. Ontario is the largest user of electric light, it having 203 of the 324 plants employed. British Columbia in this respect shows the largest proportionate increase.

Personal

Engineers everywhere know Professor Unwin, or at least know of him through his writings, and will be interested, therefore, in the announcement that he has retired from active work at the Central Technical College, of the City and Guilds, of London. The monthly journal of the college—"The Central"— has commented on the event as follows:—"It is with the very deepest regret that we have to record the approaching retirement of Professor Unwin at the end of the present session. The college will thereby lose a professor whose eminence and ability it would be presumptuous for us to speak, and whose teaching and personal influence will always be gratefully remembered by those who have been privileged to work as his students. Making, as it does, the first break in the original professorate of the college, a professorate which has raised it in a period of a little less than twenty years from small beginnings to its present position, the change is an important event in the history of the Central * * * Professor Unwin was appointed to the professorship of civil and mechanical engineering by the institute at the opening of the college early in 1884, and served as Dean from that date until midsummer, 1895, and again during the last two sessions. In 1901, when the reconstituted University of London added a faculty of engineering, Professor Unwin was made University professor in that subject. Some idea of the progress of the college during this period may be gathered from the fact that in 1877, the

PROF. W. C. UNWIN

first year in which diplomas were awarded, there were only nine granted, four of these being to students in Professor Unwin's department. Last year the record number of sixty diplomas was reached; the total number of diplomas which have been gained since the beginning of the college is 521, and in addition 395 certificates have been awarded; many more special students have worked in the college laboratories. At the present day there are over 300 regular students, while eighty students from the Royal College of Science attend a special course of lectures and laboratory work in electrical engineering at the Central. * * * The present occasion affords a favorable opportunity for old students to show that they have not forgotten their professor and their college. After due consideration, it has been decided to commemorate Professor Unwin's long connection

with the Central by founding an 'Unwin Scholarship' at the college. This will constitute a more lasting memorial than any merely personal tribute, and is the form which we feel sure Professor Unwin would prefer that any testimonial should take. The arrangements are already in the hands of an influential committee, and it only remains for every old student to assist by contributing as liberally as lies in his power."

Lyman B. Brainerd has just been elected president of the Hartford Steam Boiler Inspection and Insurance Company, of Hartford, Conn.

L. B. BRAINERD

Mr. Brainerd succeeds the late J. M. Allen in this position. The action of the board was taken on the report of the committee on nominations, consisting of Colonel Frank W. Cheney, C. C. Kimball and Atwood Collins. Mr. Brainerd came to the company in 1894 from New York, where he held the position of manager of the bond department of the Equitable Mortgage Company, and was made assistant treasurer of the Hartford Steam Boiler Inspection and Insurance Company. Five years ago he was made treasurer of the company and he will retain this office with the presidency. Mr. Brainerd is a director in the Case, Lockwood & Brainerd Company, a director of the Security Company, a trustee of the Society for Savings and is also a trustee of the Hartford Theological Seminary and chairman of its executive committee. Mr. Brainerd was born in Westchester society, town of Colchester, March 27, 1856, the son of Asa Brainerd. He received his education in the common schools and at Wilbraham Academy. His first business experience was as a canvasser for the State Mutual Fire, of Hartford. After some time he went to Jersey City and entered the employ of the Jersey City Fire Insurance Company as general agent and adjuster. He remained with this company for eight years, up to the time he entered the employ of the Equitable Mortgage Company. The office of supervising general agent was created by the directors, and Charles S. Blake, who has been with the company for several years, was elected to the position. The officers of the company now are: President and treasurer, Lyman B. Brainerd; vice-president, Francis B. Allen; secretary, Joseph B. Allen; assistant secretary, Louis F. Middlebrook; supervising general agent, Charles S. Blake.

George F. Greenwood, chief engineer and general manager of the Havana Electric Railway Company, is now on a visit to this country. He is making his headquarters at the New York offices of the Company at No. 52 Broadway.

John B. White, of J. G. White & Company, of New York, and brother of Mr. J. G. White, was married June 9, at Stoke Poges Church, Buckinghamshire, England, to Miss Stevens.

Louis Terven, E. E., has been appointed chief electrician of the Nernst Lamp Company, Pittsburg, Pa. Mr. Terven was for some time electrician of the United States Navy Yard, Port Royal, S. C., which position he resigned to enter the experimental laboratory of the Nernst Lamp Company. Later he was given charge of the chemical engineering department of that company. A second promotion in so short a time speaks well for the engineering ability of Mr. Terven.

A. L. Waterbury, who was at one time first vice-president and general manager of the Citizens Telephone Company, of Houston, Tex., has accepted a position as general manager of the sales department of the American Conduit Company. Mr. Waterbury will have his headquarters at the Chicago office of the company in the Manhattan Building.

By arrangement with the well-known electrical engineers, Messrs. Brown, Boveri & Cie., of Baden, Switzerland, the Crocker-Wheeler Company, of Ampere, N. J., have secured their alternating-current designs, patents and rights to manufacture in America, and have retained them as consulting engineers. The Crocker-Wheeler Company is now putting on the market alternating-current generators, transformers and accessories of the most approved design and construction, adapted to American practice.

According to an interview with Dr. Alexander Graham Bell, printed in the Boston "Globe," Dr. Bell's favorite working time is at night, and his mind is at its brightest from midnight on. He is then free from interruption and can give up his soul to the scientific experiments and inventions which form his life work. He never goes to bed until after 4 A. M., his usual sleeping hours being from 4 until 11. The afternoon is devoted to social and business engagements, and the night alone to reading and work.

Dr. F. A. C. Perrine has resigned his position as first vice-president of the Stanley Electric Manufacturing Company, of Pittsfield, Mass., and has been succeeded by Mr. C. C. Chesney, formerly the chief engineer of the company. Dr. Perrine's action has been prompted by the desire to take

C. C. CHESNEY

up some of his personal business and some engineering work along with his particular line of power transmission.

Dr. Schuyler Skaats Wheeler, president of the Crocker-Wheeler Company, electrical manufacturers, of Ampere, N. J., sailed recently with Mrs. Wheeler, on the White Star liner "Baltic." On the pier, he said that he had planned a coaching trip in England; but early this spring Dr. Wheeler went on an automobile tour through the south of France and returned with the American patent rights of the world-celebrated electri-

cal firm, Brown, Boveri & Cie., of Baden, Switzerland. Dr. Wheeler's commercial rivals are beginning to take a lively interest in his holiday trips.

Dodge & Day, modernizing engineers, of Philadelphia, have just completed the installation of a 340-H. P. Buckeye vertical cross-compound engine direct-connected to two General Electric 100-K. W. continuous - current, compound-wound generators for the Link-Belt Engineering Company, of Philadelphia. The same concern are at work on a three-motor, electrically - operated locomotive crane for this company, to handle beams, angle-irons and other heavy structural material for use in their new storage yard. Messrs. Dodge & Day further, in conjunction with Ballinger & Perrot, architects, are proceeding with the work of rebuilding and extending the plant of the Victor Talking Machine Company, Camden, N. J. The shops are to be electrically operated and motor drives used throughout. The work is to be completed within six months.

KERN DODGE

CHARLES DAY

The recent visit of the Institute of Mechanical Engineers of Great Britain to Milwaukee, in response to an invitation from the president of the Allis-Chalmers Company, was described by President Wicksteed, of the institution, in his speech at West Allis, as "one of the pleasantest experiences that had come to the members during their American visit."

"I do not know how these things are done," said he, "but this excursion has been perfectly managed. Two or three days ago in Chicago I met the president of this great company, and incidentally remarked to him that I had long desired, as I knew many of my fellow members had, to visit the famous engine works in Milwaukee. President Warren asked, 'when will it be convenient for you and your fellow members to come?' and I replied 'the day after to-morrow,' and here we are, transported in some sort of a magical way, quietly, comfortably, without any apparent effort, by arrangements which can only have been made over night, and yet are so admirably planned and carried out that they could not have been excelled had they been a long time in preparation. From the time we left the breakfast table in Chicago until we now return there in the evening, every movement has been thought out for us and every comfort provided. I want to say in behalf of the officers and council and members of the institution that this is the kindest and most thoughtful and most generous thing that has happened in my experience of travel. This day, in one of the model engineering works of the world, is one that no member of our institution now present will ever forget."

President Wicksteed, Secretary Worthington and other members of the institution said that in the way of industrial sights they had never seen anything more impressive than the hugh electric shop of the Allis-Chalmers Company, filled as it is with engines ranging from 30 to 12,000 H. P. in process of construction.

PROF. A. W. SMITH

It is officially announced that the successor to the late Dr. Thurston as director of Sibley College at Cornell University, is to be Professor Albert W. Smith, of Leland Stanford University. Professor Smith is a graduate of Sibley College of the class of 1878.

Charles T. Allen, of the Union Steam Pump Company, of Battle Creek, Mich., has been elected president of the City Bank, of Battle Creek. Mr. Allen's residence at that city dates from the summer of 1883, when he assumed the duties of cashier of the City Bank. In 1885 he resigned to engage in the manufacturing business, having bought an interest in the Battle Creek Machinery Company. About two years later he sold his holdings to engage with the Union Manufacturing Company, the name of that organization afterward being changed to the Union Steam Pump Company. Mr. Allen has been identified with other industrial enterprises which all have attained a marked degree of success.

Friedrich Siemens, of Berlin, one of the well-known family of electrical engineers, died last month.

Trade News

The De Beers Mines Company, Ltd., Kimberly, South Africa, have cabled an order for a third Westinghouse-Parsons steam turbine generating outfit of 1500 K. W. capacity for their power plant at Kimberly. The new turbine unit will be similar in every respect to the two which have been in operation for somewhat over a year. That a concern with the standing of the De Beers Company should install machinery built at such a distance speaks well for the confidence which they place in it. The new turbine unit will operate at 150 pounds boiler pressure, 35 degrees superheat and about 23 inches vacuum. Taking into account the altitude of Kimberly, this would be equivalent to about 27 inches vacuum at sea level. The new unit will be shipped via New York in about six months.

The central feature of the machinery exhibits at the World's Fair in St. Louis is the huge Allis-Chalmers engine coupled to a Bullock electric generator. This colossal unit is the most powerful ever placed on exhibition. The engine is capable of developing 8000 H. P. when operating condensing, at 150 pounds pressure of steam, and running at seventy-five revolutions per minute. But it is not merely a display feature; it furnishes the electric current for the now world-famous decorative lighting of the buildings and grounds, for which about 200,000 incandescent lamps are required. The exhibition authorities frequently employ it for other purposes as well, sometimes for operating the cascades and sometimes for general power purposes. Recently it was suddenly called upon to take the entire load ordinarily carried during the day by a large plant in the same building, and aggregating about 5400 H. P. Having carried this load as long as it was needed, the Allis-Chalmers giant then took up the regular light-

ing work for the evening. This engine and generator have been constantly ready for any emergency from the beginning, and have never failed to respond immediately and with complete satisfaction whenever called upon. The engine has worked perfectly ever since the steam was first admitted to its cylinders, and it is popularly known among the exhibition people as "Big Reliable."

The Federal Electric Company, formerly of Erie, Pa., have removed to Girard, Pa., where modern facilities and additional shop equipment will enable them to greatly increase their output, and facilitate the prompt and efficient handling of orders.

The Triumph Electric Company, of Cincinnati, announces the appointment of Mr. H. C. Spaulding as assistant sales manager.

The O'Rourke Engineering and Construction Company, which firm has the contract for building the Pennsylvania Railroad tunnel under the Hudson River, has placed an order with the Ingersoll - Sergeant Drill Company for two central compressed air power plants to be located at New York City and Weehawken, N. J. This order includes eight 36-inch stroke Corliss compressors, each of 3890 cubic feet capacity.

One of the several interesting features of the Westinghouse exhibit at the St. Louis Exposition is the display of the company's alternating-current, single-phase railway motors, now so prominently before the engineering world, which are introducing radical changes in present railway practice. The successful production of the alternating-current railway motor constitutes the most important electrical development of the past two years, and it is unlikely that any other single technical exhibit at the Fair will be viewed with so live an interest.

G. M. Gest, subway contractor, of New York, has been awarded the contract for the complete installatoin of an underground conduit system, including all the electrical distribution to service and house connections, for the South Bend Electric Company, at South Bend, Ind. This work covers all the main streets of that city, and will be one of the most complete and modern conduit systems so far constructed. Work is to be completed at the earliest possible moment, and a large force of men will, therefore, be employed. The Oliver Chilled Plow Works, who own their private plant at the same place, have also contracted with Mr. Gest for the construction of their underground conduit system. While not as great a system as the other, it will feed some of the most important parts of the city. Still another of Mr. Gest's contracts is that awarded by the Toronto Railway Company, of Toronto, Canada, for the construction of their entire subway system, covering the main thoroughfares of the city of Toronto. Work is to be commenced at once, and a large force of men are to be employed on it. This is part and parcel of the many improvements inaugurated in the reconstruction of the electrical equipment of this railroad which is being changed in all respects to make it absolutely modern and up to date.

At the Elks' convention, held in Cincinnati from July 8 to July 25, there are in use nearly 30,000 "Norbitt" porcelain temporary sockets for decorative purposes, illuminating the streets for thirty-seven blocks. Over 500 "Norbitt" temporary sockets are also in use in the huge American flag which is hung over Government square. These handy little devices, which can be installed in a very few moments without scraping the insulation from the wire, are manufactured by the Crouse-Hinds Company, of Syracuse, N. Y.

The Brown-Corliss Engine Company, of Corliss, Wis., have opened a department for building high-speed engines, and are now working on two units of 150 H. P., three 250 H. P., two 50 H. P. and one 75 H. P., all to be direct connected.

The Crocker-Wheeler Company, of Ampere, N. J., announces that they are now prepared to give their clients expert advice upon the latest ideas and results in shop practice, in addition to purely engineering advice upon the design and installation of electrical apparatus for shop equipment, which they have been giving for a number of years, and for which they now enjoy a considerable reputation. To this end they have retained the well-known firm of Dodge & Day, modernizing engineers, of Philadelphia, Pa. They place the services of this firm at the disposal of their customers, giving them gratuitously the benefit of its wide experience and data. The experience of the electrical engineer alone does not fully cover the numerous factors that are met in these days in the dividend-making management of machine shops. While the economies that may be effected by the electric drive are conceded by all, the actual savings accomplished depend entirely upon the intelligence with which the apparatus is selected, installed and used. The advice and recommendations about which customers may consult the Crocker-Wheeler Company need not be confined to electrical details, but may include all problems of shop equipment and management.

The Yale & Towne Manufacturing Company, of Stamford, Conn., are exhibiting at the St. Louis Exposition a complete line of chain blocks manufactured by them. Chain blocks of the triplex, duplex and differential types are shown, ranging in capacity from $\frac{1}{8}$ to 20 tons. A new electric hoist is shown in operation, and one of each of the three types of blocks are operated by electric motors to show their relative efficiency. Each block is supplied with a 1000-pound weight, and, with equal power applied to each block, the rate of lifting indicates the relative efficiency. The triplex block lifts its load much quicker than the others, and an automatic mechanism reverses the direction of all three blocks when the triplex block arrives at the top. When all three blocks have reached the floor the mechanism again reverses and the weights are hoisted.

The Railway Appliances Company of Chicago have been appointed exclusive agents for the United States for the railway trade of the Olds Motor Works, of Detroit and Lansing, Mich.

At a recent meeting of the stockholders of the Brown Corliss Engine Company, Corliss, Wis., it was decided to increase the working capital of the company to $150,000.

The Lunkenheimer Exhibit at St. Louis

A LARGE model of the familiar Lunkenheimer "Valve in Hand," serves to identify the exhibit in Machinery Hall of the Lunkenheimer Company, of Cincinnati, Ohio, manufacturers of brass and iron steam specialties and engineering appliances.

As will be seen from the illustration, pyramids of globe, angle, cross, lever and gate valves of various designs and sizes in brass and iron, are artistically arranged about the exhibit and are agreeably set off by a black plush curtain at the side and rear.

The glass cases arranged in front of the exhibit contain a smaller class of the goods manufactured by the Lunkenheimer Company, such as lu-

bricators, oil and grease cups, cocks and the like, of all sizes. Neat designs of racks, containing various sizes of whistles, injectors, pop-valves and a variety of other specialties lend to make up an exhibit worthy of notice. A new design of water gauge and oil pump for cylinder lubrication are features in themselves. Dispersed about the exhibit are pipe fittings of every description, together with whistles, safety and check valves and numerous other appliances.

The bright, polished parts of the products displayed by the Lunkenheimer Company help to attract attention to the exhibit, and the large variety of appliances shown makes more than a casual glance necessary to fully appreciate the exhibit in all its details.

THE EXHIBIT OF THE LUNKENHEIMER COMPANY, OF CINCINNATI, OHIO, AT THE ST. LOUIS EXPOSITION

New Catalogues

Drills, reamers, chucks, cutters, and taps and dies, are presented in a new catalogue of the Morse Twist Drill & Machine Company, New Bedford, Mass. A few of the machines made by the company for grinding drills and cutters are also illustrated and described. In an appendix are given a table of Morse tapers, directions for grinding drills and their proper speeds in use. Tap drill sizes, milling cutter speeds, and screw-thread tables are also contained in this portion, as well as tables of weights of square and round wrought-iron bars, and iron and steel sheets.

A new pamphlet recently issued by the Bullock Electric Manufacturing Company, Cincinnati, Ohio, is devoted to multipolar motors and generators. Several parts of the machines are shown and described in detail, illustrations are given of some installations, and tabulated ratings and dimensions of the various types and sizes are also contained in this catalogue.

The Green traveling link grate, made by the Green Engineering Company, Chicago, Ill., is described and illustrated in a catalogue recently issued. The grate is illustrated and described in detail, and views of several installations are given. The pamphlet also contains tables of approximate analyses and calorific values of the coals mined in Pennsylvania, Ohio and Illinois.

The Elbridge Electrical Manufacturing Company, Elbridge, N. Y., have issued a series of four bulletins devoted to motors and dynamos of their make. The machines are of small size and are designed for a lighter grade of work, for sparking in connection with gas engines, and for experimental work in schools and colleges, the last named being arranged for hand operation. A price list also accompanies the pamphlet.

The current for the operation of the Intramural Railway at the St. Louis Exposition is furnished by seven generators built by the Crocker-Wheeler Company, Ampere, N. J., and these machines are described, with illustrations, in a pamphlet recently issued by the company. A plan of the Fair Grounds is also given showing the location of the company's exhibit in Machinery Hall. Every building plan will prove of value to a visitor at the Exposition.

A new leaflet circulated by the Northern Electrical Manufacturing Company, Madison, Wis., deals with motors for operating blowers and ventilating fans, and is profusely illustrated.

The third number of "The Progress Reporter," issued by the Niles-Bement-Pond Company, of New York, is devoted to the more important machines shown by the company at the St. Louis Exposition. The large machines illustrated are motor-driven and afford good examples of the latest adaptation of the motor-drive to machine tools. The engravings are excellent and the pamphlet is typographically of a high order throughout.

Glass insulators and malleable iron pins for mine feeder wires are illustrated and described in a circular issued by the Jeffrey Manufacturing Company, of Columbus, Ohio.

A booklet illustrating and describing transformers has been recently issued by the General Electric Company, Schenectady, N. Y. The qualities necessary in a transformer for successful operation are briefly discussed, and the construction, to acquire these qualities, of the transformers made by the company is fully illustrated and explained. A bulletin, also issued by the company, is devoted to the Sprague-General Electric control system. The working of the system and its general features are described with views of the general arrangement of parts and connections to them. The apparatus used in the system is also illustrated and briefly described. Another bulletin deals with a new design of Thomson high-torque induction meter. The meter is shown assembled, the various parts are described in brief, and the important characteristics of this type are also considered. Tables of capacities with list prices are given as well as dimensions of meters for house use. "Flyers" on alternating-current buzzers and spring switches with fuse plugs have also been sent out, with separate price lists on fan motors, Meridian lamps, Edison street series incandescent lamps, repair parts of 22-volt direct-current, enclosed arc lamps and lightning arresters.

The Marsh tank and vacuum pumps made by the American Steam Pump Company, Battle Creek, Mich., are illustrated and described in a new catalogue issued by that company. Tables of dimensions and capacities are given, with list prices of each type shown, and a list also appears of the various other pumps made by the company.

Electrical Exhibitors at the St. Louis Exposition

THROUGH the courtesy of Chief W. E. Goldsborough, of the Department of Electricity at the St. Louis Exposition, we are enabled to print the following list of electrical exhibitors:—

Adams-Bagnall Electric Co., Cleveland, Ohio.
A. S. Aloe, St. Louis, Mo.
American Carbon & Battery Co., St. Louis, Mo.
American Circular Loom Co., Chelsea, Mass.
American Electric Fuse Co., Chicago., Ill.
American Electrical Heater Co., Detroit, Mich.
American Electrical Novelty & Mfg. Co., New York.
American School of Correspondence, Chicago, Ill.
American Telephone & Telegraph Co., Boston, Mass.
The American Watchman's Time Detector Co., New York .
American Watchman's Time Detector Co., Cleveland, Ohio.
Bion J. Arnold, Chicago, Ill.
Association of Edison Illuminating Companies, Chicago, Ill.
Martin Armstrong. St. Louis, Mo.
Atlanta Utility Works, East Point, Ga.
The Automatic Electric Co., Chicago, Ill.
Automatic Fire Alarm Co., New York.
Baird Mfg. Co., Chicago, Ill.
Carl Bajohr, St. Louis, Mo.
Barion Vacuum Co., New York.
M. V. Barlow, Chicago, Ill.
Mrs. Alexander Baumgart, New York.
Banjamin Electric Mfg. Co., Chicago, Ill.
The Bristol Co., Waterbury, Conn.
The Browning Co., Milwaukee, Wis.
The Bryant Electric Co., Bridgeport, Conn.
Bullock Electric Mfg. Co., Cincinnati, Ohio.
Burdette-Rountree Mfg. Co., Chicago, Ill.
Burnham, Williams & Co., Philadelphia, Pa.
H. B. Camp Co., Chicago, Ill.
Carbondale Machine Co., Carbondale, Pa.
Carman Projector & Specialty Co., Chicago, Ill.
Central Telephone & Electric Co., St. Louis, Mo.
Chicago Fuse Wire & Mfg. Co., Chicago, Ill.
Chicago X-Ray Co., Chicago, Ill.
Jas. Clark, Jr., & Co., Louisville, Ky.
A. Frederick Collins, New York.
Commercial Electric Co., Indianapolis, Ind.
Controller Co. of America, St. Louis, Mo.
Cooper-Hewitt Electric Co., New York.
Crocker-Wheeler Co., Ampere, N. J.
The Dayton Autoelectric Co., New York.
De Forest Wireless Telegraph Co., New York.
Patrick B. Delany, South Orange, N. J.
The Dayton Electrical Mfg. Co., Dayton, Ohio.
Dicke Tool Co., Downers Grove, Ill.
Dodd & Struthers, Des Moines, Ia.
S. R. Dresser, Bradford, Pa.
Economical Electric Lamp Co., New York.
Thomas A. Edison, Orange, N. J.
Electra Water Purifying Co., St. Louis, Mo.
Electric Calculator Co., Chicago, Ill.
Electric Contract Co., New York.
Electric Controller & Supply Co., Cleveland, Ohio.
Electric Railway Equipment Co., Cincinnati, Ohio.
Electric Storage Battery Co., Philadelphia, Pa.
Eureka Tempered Copper Works, North East, Pa.
Faler Automatic Telephone Exchange Co., New York.
Federal Electric Co., Chicago, Ill.
C. J. Field, New York.
Fort Wayne Electric Works, Fort Wayne, Ind.
The Gardner Electric Drill & Machy. Co., Cleveland, Ohio.
General Electric Co., Schenectady, N. Y.
Gervais Mfg. Co., Edgewater, N. J.
G. M. Gest, Cincinnati, Ohio.
W. E. Goldsborough, LaFayette, Ind.
Gould Coupler Co., New York.
Could Storage Battery Co., Depew, N. Y.
Gray National Telautograph Co., New York.
Gray Telephone Pay Station Co., Hartford, Conn.
A. Grothwell, San Francisco, Cal.
Roberty E. Hayward, Kansas City, Mo.
The Heinze Electric Co., Lowell, Mass
Hellens, Enke & V. Ludvigsen, Copenhagen, Denmark.
C. F. Hall, Chicago, Ill.
Hinton & Tarkington, Hot Springs, Ark.
Holmes, Booth & Haydens Co., New York.
Holophane Glass Co., New York.
C. W. Hunt, West New Brighton, N. Y.
Miller Reese Hutchison, New York.
Hutchison Acoustic Co., New York.
Indiana Novelty Co., Muncie, Ind.
International Acheson Graphite Co., Niagara Falls, N. Y.
J. Van Inwagen, Momence, Ill.
The Jackson Electric Drill & Supply Co., Denver, Col.
The Jandus Electric Co., Cleveland, Ohio.
Charles Kaestner & Co., Chicago, Ill.
Kellogg Switchboard & Supply Co., Chicago, Ill.
Kester Electrical Mfg. Co., Chicago, Ill.
Keystone Electrical Instrument Co., Philadelphia, Pa.
The Kny-Scherer Co., New York.
D. A. Kusel Telephone & Electric Mfg. Co., St. Louis, Mo.
The Leclanche Battery Co., New York.
Lincoln Electric Co., Cleveland, Ohio.
Lionel Mfg. Co., New York.
Locke Insulator Mfg. Co., Victor, N. Y.
McGraw Publishing Co., New York.
McRoy Clay Works, Chicago, Ill.
Marshall-Sanders Co., Boston, Mass.
W. E. Matthews & Bro., St. Louis, Mo.
The Miller Anchor Co., Norwalk, Ohio.
Moloney Electric Co., St. Louis, Mo.
National Carbon Co., Cleveland, Ohio.
S. W. Stratton, Washington, D. C.
National Battery Co., New York.
National Cash Register Co., Dayton, Ohio.
National Electric Co., Wilwaukee, Wis.
Nernst Lamp Co., Pittsburg, Pa.
Northern Electrical Mfg. Co., Madison, Wis.
Norton Emery Wheel Co., Worcester, Mass.
Nungesser Electric Battery Co., Cleveland, Ohio.
The Organ Power Co., Hartford, Conn.
Pawling & Harnischfeger, Milwaukee, Wis.
The Peerless Electric Co., Warren, Ohio.
Perkins Electric Switch Mfg. Co., Bridgeport, Conn.
The Phelps Co., Detroit, Mich.
Walter P. Phillips, Bridgeport, Conn.
Pittsburg Blue Print Co., Pittsburg.
Pneumatic Signal Co., Rochester, N. Y.

Postal Telegraph Cable Co., St. Louis, Mo.
Printing Telegraph News Co., St. Louis, Mo.
Prometheus Electric Company, New York City.
Purdue Research Laboratory, La Fayette, Ind.
F. Herrero y Ruiz, Albacete, Spain.
Reynolds Electric Flasher Mfg. Co., Chicago, Ill.
The Robbins & Myers Co., Springfield, Ohio.
Chicago Roentgen X-Ray Laboratory, Chicago, Ill.
Roth Bros. & Co., Inc., Chicago, Ill.
St. Louis Brass Mfg. Co., St. Louis, Mo.
The Safety Insulated Wire & Cable Co., New York.
Sawyer-Man Electric Co., New York.
W. Scheidel & Co., Chicago, Ill.
M. Schearer, Akron, Ohio.
Shedd Electric & Mfg. Co., New York.
Standard Underground Cable Co., Pittsburg, Pa.
Standard Water Purifying Co., Cleveland, Ohio.
Sterling Electric Motor Co., New York.
Sterling Electric Motor Co., Dayton, Ohio.
William F. Stilz & Co., Philadelphia, Pa.
Sumter Telephone Mfg. Co., Sumter, S. C.
Telephone Hygienic Co., Los Angeles, Cal.
C. J. Toerring Co., Philadelphia, Pa.
Triumph Electric Co., Cincinnati, O.
Underwriters' Laboratories, Chicago, Ill.
United States Electric Signal Co., West Newton, Mass.
E. C. Van Nor Electric Co., St. Louis, Mo.
Wagner Electric Mfg. Co., St. Louis, Mo.
R. V. Wagner & Co., Chicago, Ill.
Waite & Bartlett New York.
Warren Ball-Bearing Fixture Co., New York.
Warren Electric & Specialty Co., Warren, Ohio.
Warren Electric Mfg. Co., Sandusky, Ohio.
B. F. Wasson, Clinton, Ill.
Western Electric Co., Chicago, Ill.
Wesco Supply Co., St. Louis, Mo.
Western Electrician Chicago, Ill.
Western Union Telegraph Co., St. Louis, Mo.
Weston Electrical Instrument Co., Newark, N. J.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.
Wheel Truing Brake-Shoe Co., Detroit, Mich.
Windsor & Kenfield Publishing Co., Chicago, Ill.
Wireless Railway Co., Philadelphia, Pa.
The Wyckoff Pipe & Creosoting Co., Stamford, Conn.
Charles E. Yetman, New York.
National Clock Works, St. Louis, Mo.
The Colonial Sign Co., Akron, Ohio.
U. S. Incandescent Lamp Co., St. Louis, Mo.
Westinghouse Traction Brake Co., New York.
Mexico.
H. E. King, Chicago, Ill.
Cassidy & Son Mfg. Co., New York.
W. M. Bashlin, Warren, Pa.
Italy.
France.
Germany.
Mystic Electric Gas Lighter Co., New York.
C. H. Thordarson, Chicago, Ill.
Dialt Motor Co., Philadelphia, Pa.
Portugal.

The International Electrical Congress

ST. LOUIS, SEPTEMBER 12-17.—GENERAL PROGRAMME

A GENERAL programme has been issued by the International Electrical Congress reception committee of the American Institute of Electrical Engineers, giving particulars of the tour arranged by the Institute for visiting foreign electrical engineers.

According to this, the Congress will convene at St. Louis, beginning at 9:30 A. M., on Monday, September 12, 1904. The opening ceremonies will be held in the music hall of the Coliseum, at Olive and Thirteenth streets. The meetings of the eight sections will follow, commencing at 11 o'clock A. M., in the section halls on the second floor of the Coliseum, the sections adjourning on Monday, at 1:30 o'clock P. M.

On Tuesday, Thursday and Friday the sections will meet on the second floor of the Coliseum at 9 o'clock A. M., and will adjourn not later than 1 o'clock, P. M.

On Wednesday, at 10 o'clock, A. M., the annual convention of the American Institute of Electrical Engineers will be formally opened at Festival Hall, in the grounds of the Louisiana Purchase Exposition, and the president of the Institute, Bion J. Arnold, will then deliver the annual address. Immediately afterward a topical discussion will follow between the Institution of Electrical Engineers of Great Britain and the American Institute of Electrical Engineers, the subject of which will be announced later. Arrangements are being made for holding a closing meeting of the Congress, probably in one of the buildings in the grounds of the Exposition.

The International Electrical Congress is held under the auspices of the Louisiana Purchase Exposition, and the following bodies in America are co-operating in holding it: The American Institute of Electrical Engineers, the American Electrochemical Society, the American Physical Society, the National Electric Light Association, the Association of Edison Illuminating Companies, the International Association of Municipal Electricians and the American Electro-Therapeutic Association.

The committee of organization of the Congress is:—

President, Elihu Thomson, past president of the American Institute of Electrical Engineers.

Vice-presidents, B. J. Arnold, president of the American Institute of Electrical Engineers; Prof. H. S. Carhart, president of the American Electrochemical Society; Prof. W. E. Goldsborough, chief, Department of Electricity, Louisiana Purchase Exposition; Chas. F. Scott, past president of the American Institute of Electrical Engineers; Dr. S. W. Stratton, director of the National Bureau of Standards of the United States.

General secretary, Dr. A. E. Kennelly, past president of the American Institute of Electrical Engineers.

Treasurer, W. D. Weaver.

Advisory Committee, B. A. Behrend, C. S. Bradley, J. J. Carty, A. H. Cowles, F. B. Crocker, past president A. I. E. E.; Louis Duncan, past president A. I. E. E.; R. A. Fessenden, W. J. Hammer, Carl Hering, past president A I. E. E.; C. P. Matthews, Ralph D. Mershon, K. B. Miller, W. J. Morton, E. L. Nichols, R. B. Owens, F. A. C. Perrine, M. I. Pupin, H. L. Doherty, J. W. Richards, past president of the American Electrochemical Society; H. J. Ryan, Wm. Stanley, C. P. Steinmetz, past president A. I. E. E.; L. B. Stillwell, J. G. White, A. J. Wurts.

The committee of organization has invited all who are interested in electricity and its application to join the Congress and to attend its meetings. The proceedings of the Congress will be subsequently published in either two or three large volumes, and a copy sent to each member subscribing to the Congress.

Up to the 22d of June, 1778 persons had signified their desire to become members of the Congress, of whom 286 were residents of countries outside the United States and Canada. Up to the same date 104 American papers and 56 foreign papers had been promised. The fee for membership in the Congress is $5, which may be forwarded either to the secretary, Dr. A. E. Kennelly, Harvard University, Cambridge, Mass., or to the treasurer, Mr. W. D. Weaver, 114 Liberty street, New York City. Between September 12th and September 17th the office of the secretary and of the treasurer will be at the Coliseum, St. Louis, Mo.; before and after that date they will be at the addresses given above.

In connection with the International Electrical Congress a Chamber of Delegates will be held, these delegates being appointed by the various governments, and the proceedings will be conducted in a manner essentially similar to the meetings of the Chambers of Government Delegates at the International Electrical Congresses of Chicago in 1893, and of Paris in 1900. Switzerland, Norway, Sweden, India and Mexico have already appointed delegates to represent their respective governments, and a similar action is expected to be taken in the near future by the United States, Great Britain, France, Germany, Austria-Hungary, Belgium, Italy, Denmark, Spain, Portugal, Australia, Japan, China, Brazil, Chili and Peru.

The work of the Congress will be divided into eight sections as follows:—

Section A, subject "General Theory"; chairman, E. L. Nichols, Cornell University; secretary, H. T. Barnes, McGill University.

Section B, subject "General Applications;" chairman, C. P. Steinmetz, Union College; secretary, Samuel Sheldon, Brooklyn, N. Y.

Section C, subject "Electrochemistry;" chairman, H. S. Carhart, University of Michigan; secretary, Carl Hering, Philadelphia, Pa.

Section D, subject "Electric Power Transmission;" chairman C. F. Scott, Pittsburg, Pa.; secretary, Louis Bell, Boston, Mass.

Section E, subject "Electric Light and Distribution;" chairman, J. W. Lieb, Jr., New York; secretary, Gano S. Dunn, New York.

Section F, subject "Electric Transportation"; chairman, Louis Duncan, Mass. Inst. Technology; secretary, A. H. Armstrong, Schenectady, N. Y.

Section G, subject "Electric Communication;" chairman F. W. Jones, New York; secretary, B. Gherardi, New York.

Section H, subject "Electro-therapeutics;" chairman, W. J. Morton, New York; Secretary, W. J. Jenks, New York.

The chairmen and secretaries of the various sections are also honorary members of the advisory committee of organization.

The American Institute of Electrical Engineers has extended an invitation to the Institute of Electrical Engineers of Great Britain to visit the United States in September, and to hold a joint meeting in St. Louis in connection with the International Electrical Congress. This invitation has been accepted by the Institution of Electrical Engineers, and a large number of its members, many accompanied by ladies, are expected to arrive in this country by the White Star steamship "Republic," reaching Boston September 2d.

A general invitation has also been extended to European electrical engineering societies to join in a circular tour, visiting principal cities and important industrial centers. A number of acceptances have already been received from European electrical engineers and a large delegation of the Associazione Elettrotecnica Italiana, with a number of ladies, is expected to arrive in New York August 24th, and the subsequent days up to September 2d, when they will proceed to Boston, joining the main party there on September 3.

A general reception committee and a committee on transportation and arrangements have been appointed by the president of the American Institute of Electrical Engineers and local reception committees have been appointed in the cities which are included in the itinerary of the special circular tour.

The chairman of the general reception committee, with headquarters in New York, is J. W. Lieb, Jr., president elect of the American Institute of Electrical Engineers, and third vice-president and associate general manager of the New York Edison Company. The chairmen of the local reception committees in the order in which the cities are to be visited are as follows:—

Boston—C. L. Edgar, president of the Edison Electric Illuminating Company, of Boston.

New York—T. Commerford Martin, editor of the "Electrical World and Engineer."

Schenectady—E. W. Rice, Jr., technical director and third vice-president of the General Electric Company.

Montreal, Canada—R. B. Owens, professor of electrical engineering, McGill University.

Niagara Falls—Geo. W. Davenport, vice-president and general manager of the Niagara Falls Power Company.

Chicago—Samuel Insull, president of the Chicago Edison Company.

St. Louis—W. V. N. Powelson, vice-president and general manager of the Union Electric Light and Power Company, Mr. W. A. Layman, chairman, committee of arrangements.

Pittsburg—Chas. F. Scott, chief electrician, the Westinghouse Electric and Manufacturing Company.

Washington—George H. Harries, vice-president Washington Railway and Electric Company.

Philadelphia—Joseph B. McCall, president of the Philadelphia Electric Light Company.

The chairman of the committee on transportation and arrangements is Mr. E. H. Mullin, 44 Broad street, New York.

Arrangements have been made in Boston to receive the visiting members of the Institution of Electrical Engineers at the wharf. The local reception committee in Boston has arranged to take the visiting engineers on a visit to the power houses in Boston, to the Massachusetts Institute of Technology and to Harvard University, where a reception will be held on Saturday, September 3d. After the reception the visitors will leave by train for Providence, where they will take the steamer for New York, arriving Sunday morning, September 4th. A rate has been made inclusive of all expenses in Boston, from the wharf, including accommodations at the Vendome Hotel and steamboat to New York City for $13. This sum will cover all expenses from the time the English visitors arrive in Boston on Friday until they reach New York by steamer on Sunday morning.

For the convenience of the foreign visitors arriving at New York on or prior to September 1st, and who will proceed to Boston to join the main party, an excursion has been arranged via Newport, leaving New York by steamer on the evening of Thursday, September 1st, at 5:30 o'clock P. M. After spending a day at Newport those who go on this excursion will proceed to Boston, arriving there at 7:13 P. M. of the same day in time to join the main party in seeing Boston on Saturday, September 3d. A rate has been arranged for this round trip, from New York to Boston, via Newport and direct return, including hotel expenses in Boston, of $19.25, covering return by steamer with the members of the Institution of Electrical Engineers.

On account of the number and diversity of hotels in New York no ar-

rangements have been made to locate the visitors at any one hotel, and the expenses of the stay in New York City are not, therefore, included in the price of the round trip referred to later, but the following rates for hotels are given, and the chairman of the committee on transportation and arrangements will be very glad to make any reservations in acordance with this schedule:—

Waldorf-Astoria, European plan, $2 per day and upwards.

Holland House, European plan, $3 per day and upwards.

Fifth Avenue, European plan, $2; American plan, $4 per day and upwards.

Park Avenue, European plan, $2; American plan, $4 per day and upwards.

Wolcott, European plan, $2; American plan, $4 per day and upwards.

Gregorian, European plan, $2; American plan, $4 per day and upwards.

Marlborough, European, $1.50 and upwards; American, $3.50 a day and upwards.

The Lafayette-Brevoort, European, $1.50 per day and upwards.

Both the Lafayette and the Lafayette-Brevoort are much frequented by visitors from France and Italy.

Should ten or more visiting electrical engineers arrange to stop at the same hotel an endeavor will be made to secure special rates at the Park Avenue or at the Lafayette-Brevoort.

For convenience in night journeys and for use between stops at hotels, it is recommended that a commodious hand bag or dress suit case be provided, which can be taken in the section or compartment on the train where trunks would be inaccessible. Light weight clothes should be worn, with light weight underwear, with a suit of medium or heavy underwear in reserve.

Traveling rugs are entirely unneccessary. Formal morning and afternoon dress will not be required when making visits from the train, but may be desirable in visits from the hotel at New York, Montreal, St. Louis and at Washington.

While in New York on Sunday afternoon, September 4th, the visiting electrical engineers and all the members of the American Institute of Electrical Engineers, will be the guests of Messrs. J. G. White & Company on a steamboat excursion either up the Hudson or down to Coney Island, as may be arranged later. On Monday, September 5th, the visiting engineers and the members of the American Institute of Electrical Engineers, as guests of the New York reception committee, will make a tour of the electrical power stations of New York City. On the evening of September 5th a reception and dinner will be given by the American Institute of Electrical Engineers to all the foreign visitors.

In order that the visiting members of the Institution of Electrical Engineers and other visiting electrical engineers may have an opportunity of seeing as many as possible of the larger cities of the country and important centers of electrical development, within the time which can be spared, a special circular tour has been arranged by the American Institute of Electrical Engineers. It is strongly recommended that as many as possible of the visitors from abroad avail themselves of this tour, as it will afford an exceptional opportunity of visiting many of the important points and places of interest with the greatest economy of time and at the minimum of expense. It will also afford the local reception committee a much desired opportunity of extending to the visiting electrical engineers the hospitality of their respective cities.

The circular tour will be by special train composed of Pullman drawing room and sleeping cars, and will leave the Grand Central Station of the New York Central and Hudson River Railroad at 8:45 A. M., on Tuesday, September 6th. This train will run along the east bank of the Hudson River as far as Albany, giving views of the Palisades and of the Highlands of the Hudson. West Point, where cadets are trained for commissions in the United States Army, is situated on the west bank of the Hudson, about 50 miles from New York. Leaving Albany the train will pass into the beautiful Mohawk Valley, and at 12:45 P. M. reaching Schenectady, where the chief offices and principal works of the General Electric Company are situated.

The visitors will be entertained at luncheon by the General Electric Company, and will be afterwards shown through the works. In the evening special high-speed trolley cars will take the visitors to Albany, where dinner will be served at the Ten Eyck Hotel. The special train will leave Albany at 8:30 P. M., over the Adirondack route of the New York Central Railroad and will arrive at Montreal at 7:30 A. M., September 7th. After breakfast at the Windsor Hotel, where the party will stay while in Montreal, the day will be spent in visiting the local power plants, and a reception will be given in the afternoon at McGill University. In the evening the party will be the guests at dinner of the Montreal local reception committee. The next day, Thursday, September 8, will be spent in visits around Montreal and perhaps an excursion to Shawinigan Falls or in shooting the Lacine Rapids. The train will leave Montreal that evening at 8 o'clock, and will arrive next morning at Niagara Falls at 9 o'clock, September 9th, breakfast being furnished on the train from 7 o'clock A. M. The forenoon at Niagara will be spent in visiting the falls together with a trip down to the gorge to view the whirlpool and the rapids. After luncheon, at which the party will be the guests of the Niagara local committee, a visit will be paid to the power houses of the Niagara Falls Power Company, the Niagara Falls Hydraulic Power Company and to some of the electro-chemical manufactories to which power is supplied by these companies. The train will leave Niagara at 6 P. M., by the Michigan Central Railroad, dinner being served on dining cars after the departure of the train.

Passing through Canada and the city of Detroit, Mich., Chicago will be reached at 7:30 A. M., September 10th. During the day the party will be the guests of the Chicago local reception committee, and visits will be paid to the power stations, public parks and other points of interest.

The train will leave for Chicago by the Illinois Central at 11:45 P. M., and will arrive next morning at Springfield, at 7:30 A. M., Sunday, September 11. Breakfast will be served at the Leland Hotel after the arrival of the train, and a trip in trolley cars will be made to Lincoln's tomb.

St. Louis will be reached at noon of the same day, September 11th, and on arrival, the party will be taken to the Jefferson Hotel, which most of the party will make their headquarters during their stay in St. Louis. The same evening, after dinner, an informal reception will be held at the hotel.

The International Electrical Congress will open at 9:30 A. M., on Monday, September 12th, and the proceedings until Saturday, September 17th, will be as already outlined. The train will leave St. Louis by the Pennsylvania lines at 8 o'clock P. M. on Saturday, September 17th, and will arrive in Pittsburg on Sunday afternoon at 3 P. M., September 18th, breakfast and luncheon being served en route. On arriving at Pittsburg, the visitors will go to the Shenley Hotel.

On Monday, September 19th, special trolleys will take the visitors to the offices and works of the Westinghouse Electric and Manufacturing Company at East Pittsburg. After visiting these works the party will be

the guests of the Westinghouse Electric and Manufacturing Company at luncheon. In the afternoon visits will be paid to the Edgar Thomson Steel Works and to the foundries of the Westinghouse Air Brake Company.

The visitors will leave Pittsburg the same evening at 9:30 o'clock, and will arrive in Washington at 7:30 A. M., September 20th. Breakfast will be served at the New Willard Hotel, and a visit will be paid to the recently erected offices and laboratories of the United States Bureau of Standards, which will then be formally dedicated. At luncheon the visitors will be the guests of the Washington local reception committee, and after luncheon a visit will be paid to the White House and other points of interest.

The train will leave Washington at 8 o'clock the same evening, arriving at Philadelphia at 11 o'clock P. M., where the guests will stay at the Bellevue-Stratford Hotel. On the morning of September 21st, visits will be paid to the power houses, to Independence Hall and other points of technical interest in Philadelphia. The party will be the guests at luncheon of the Philadelphia local reception committee and will leave the same afternoon at 3:30, arriving in New York at 5:30 P. M.

This brief outline of the programme arranged for the circular tour will be supplemented later by detail programmes for the various cities, outlining special features of entertainment prepared by the local reception committees, which will in many cases include special and separate entertainments for the ladies of the party,

The cost of a ticket for the tour, including railroad fares, sleeping car berths, hotel accommodation (St. Louis also), meals and all necessary expenses from New York following the itinerary above outlined and back to New York will be $150. This rate, however, does not include hotel expenses in New York City or the expense of the Boston trip previously referred to, and does not include admission to the grounds of the Louisiana Purchase Exposition.

Tickets for the special trip from Boston to New York, as above outlined, and costing $13, can be obtained on September 2d and on September 3d by personal application at the headquarters of the Boston local reception committee of the A. I. E. E., at the Hotel Vendome, Boston, Mass.

Tickets for trip of New York to Boston and return, as above specified, and costing $19.25, and for special circular tour from New York to St. Louis and return, costing $150, can be obtained by personal application at the headquarters of the New York local reception committee of the A. I. E. E., at the Waldorf-Astoria between August 29th and September 5th, 1904, inclusive.

At Boston and New York headquarters a special representative of the A. I. E. E. will be on hand to facilitate the purchase of tickets and give any desired information in reference to the trips.

Those desiring to purchase their tickets for special trips and circular tour before arrival in the United States can do so through the secretaries of the electrical engineering societies of which they are members and from whom they come accredited. The secretaries of these societies can transmit such applications with remittance to Mr. Ralph W. Pope, secretary, the American Institute of Electrical Engineers, No. 95 Liberty street, New York City.

For the benefit of visiting electrical engineers who may find it impossible to accompany the main body of the visitors on the circular tour above described, the following information may be of use:—

Travelers between New York and St. Louis and return may choose any one of a number of routes. Trains by the New York Central and Hudson River Railroad, the West Shore Railroad, the Erie Railroad, the Lehigh Valley Railroad and the Delaware, Lackawanna and Western Railroad pass through Buffalo, and all these roads allow a stop over not exceeding ten days at Niagara Falls, about 20 miles from Buffalo. Trains by the Pennsylvania Railroad pass through Philadelphia and Pittsburg. Travelers by the Pennsylvania Railroad and the Baltimore and Ohio Railroad may stop over not more than ten days at Philadelphia, Baltimore or Washington. Excursion rates from New York to St. Louis are as follows:—

Season excursion tickets available for return until December 15, $38.80. Sixty-day tickets available for return within two months, $32.35. Fifteen-day tickets, available for return within two weeks, $26.25.

Season excursion tickets are good on all trains, but on trains on which an extra fare is charged, the additional amount must be paid. Sixty-day excursion tickets are good on all trains from St. Louis, but are not good on the Twentieth Century, limited, or the Empire State Express trains of the New York Central and Hudson River Railroad. Fifteen-day excursion tickets are good on the Lake Shore limited, between New York and St. Louis, provided the holders of them are located in the St. Louis car. All three classes of tickets will be honored for transportation on Pullman cars, by paying additional Pullman charge. The rate for a half section—that is, a lower or an upper berth on a Pullman car between New York and St. Louis—is $6.

Season and sixty-day tickets from New York to St. Louis and return may also be purchased going by one route and returning by another; but travelers who wish to buy such tickets should be careful to make up their minds beforehand about the return route, as these tickets cannot be changed after they have been issued.

All foreign electrical engineers who may visit the United States in connection with the International Electrical Congress are invited to take part in the circular tour. It is expected, however, that they shall come properly accredited by the electrical engineering society of which they are members. The foreign visitors will be accompanied during the circular tour by representatives of the American Institute of Electrical Engineers, many of whom will be accompanied by ladies, to act as guides to the visitors. This representation will include members of Council of the American Institute of Electrical Engineers, of the Council elect, and the general reception, also committee on organization, advisory committee and chairmen and secretaries of sections of the International Electrical Congress, officers of the National electrical engineering societies co-operating with the Congress, American reception committees of the foreign societies and members of the A. I. E. E. who may be assigned as special guides to accompany the party. It is desired that as many as possible of the American representatives be accompanied by their ladies to assist in entertaining the visiting ladies.

Foreign electrical engineering societies who may take part in the tour, represented by a delegation of their membership, and foreign visiting electrical engineers who desire to accompany the party, are requested to make application at once, giving their names, address and the electrical engineering society with which they are affiliated and from whom they come accredited, stating when they expect to arrive in the United States, and at what port, to Mr. Ralph W. Pope, secretary, American Institute of Electrical Engineers, 95 Liberty street, New York City, to whom all communications respecting the circular tour should be addressed. To him also should be addressed all letters, telegrams, etc., for those participating in the tour, and while they are en route, and his office will forward them to the nearest stopping place.

From the World's Technical Press

The Cost of Municipal Electric Lighting

THE Mayor of Chattanooga has been making some comparisons of the cost of lighting in cities which buy their light from private companies and those which own and operate their own plants. In a recent interview, according to "The Municipal Journal and Engineer," he drew attention to the contrast afforded by the low cost, per arc lamp, at which Nashville is lighted as compared with the much higher price paid by his own city. The former is a municipal plant and the latter is owned by a private company. Chattanooga pays $85 per arc lamp, while the same service costs Nashville a trifle less than $50, making a difference in favor of Nashville of $35 per arc lamp.

It is interesting, therefore, to note the following statement made by former Mayor Head, of Nashville, to Mayor Chambliss, of Chattanooga:—

"The total cost for lighting the city under the contract system had for several years been about $49,000 per annum, and the actual cash paid by the city for lighting the streets and public buildings for the year 1901 was $47,302.75. This gave to the city 382 arc lights, the outages and inefficiencies of which kept the city in a constant broil with the company on the one hand and with the citizens on the other.

"On October 1 the city accepted from its contractors its newly constructed electric plant at a cost of $140,063.73, which included the cost of the site and the building. Additions were gradually made until the total cost had run up to $153,980.66. The actual cost of operating this plant for twelve months has been $35,162.96, which includes interest on bonds, betterment, etc. This is for 630 arc lights and 1961 incandescent, as against 382 previously furnished. The total expense of operating the municipal plant from October 1, 1902, to October 1, 1903, was $35,162.96. Had the light now being furnished to the city been supplied by the private company under the contract in force at the time the city took charge of its own lighting, it would have cost the city on a basis of the present number equal to 822 arc lights, $69,870, or $22,567.25 per year more than the city was paying in 1901, before it built its plant, and $34,707.04 more than it costs now.

"After the city had finally decided to construct this plant, the private company, which was then charging its customers 18 cents per kilowatt, before the foundations for the city's plant were completed, voluntarily reduced its price to private consumers from 18 cents to 12 cents per kilowatt, and contracts are now being made with the private company for a term of years at 5 cents per kilowatt. The actual cost to the city, using its own plant, for producing electricity during the past twelve months has been 2.65 cents per kilowatt."

Indicating a Steam Turbine

WHILE the steam engine indicator cannot help to give us a steam turbine diagram that would mean anything, the statement, often made, that the steam turbine cannot be "indicated," is not altogether true.

Writing in "The Electrical Review," of London, Mr. William H. Booth says that the pressure in the turbine can be gotten at any part of its length, and from this something can be learned of the behavior of the steam within, and particularly of the effects of superheated steam. Where saturated steam is employed in the turbine, its temperature at any point can be ascertained by means of a mercury pocket of thin brass let into the body of the outer casing. A series of these pockets, fitted along the length of the turbine, and fitted with thermometers, will give a series of temperature readings at such points which can be plotted as a curve of pressures by aid of a steam table, or the thermometers may be graduated in pounds to avoid translation. A series of pressure gauges may also be used, and will correspond with the thermometer readings at the same section. The rate of expansion can be found in this manner as an aid in fixing upon the dimensions and proportions of the several parts.

Where superheated steam is employed, the difference of the readings of the pressure gauges and of the thermometers will show the extent to which the superheat is retained as the steam travels through the turbine. The constancy of the conditions in a turbine on a steady load renders such method of investigation easy and reliable, in which the turbine differs from the reciprocating engine, the results from which, by any similar method, would be at least speculative only.

The Importance of Selenium in Electrical Industry

AT the recent meeting of the Elektrotechnischer Verein, Berlin, E. Ruhmer delivered an address on the importance of selenium for the electrical industry, an abstract of which appears in "The Scientific American" of recent date. After giving an historical sketch of the discovery of selenium by the Swedish scientist, Prof. Berzelius, Mr. Ruhmer briefly explained the properties of the various modifications of this body.

The sensitiveness to light characteristic of the crystalline modification has been utilized in connection with the design of the so-called selenium cells, consisting mainly of a selenium resistance prepared after a special process, so as to afford the highest sensitiveness to light. As by the increase

in the conductivity of selenium, due to illumination, the current intensity in a circuit is altered, these devices will act in a way quite similar to an electric cell proper.

Mr. Ruhmer showed by some interesting experiments the fluctuations in the intensity of a current traversing the selenium cell, as produced by variations in the luminous intensity. A glow lamp connected in series with a selenium cell was, for instance, shown to give a dark-red light while the selenium cell was in the dark, while an intensely white glow was noted as soon as the cell was exposed to the action of light. The action of extremely rapid fluctuations in the luminous intensity was illustrated with the aid of a rotating disc, having circular rows of holes, through which a selenium cell was illuminated.

The cell was connected to a battery and a loud-speaking telephone, which, with the alternating illumination and darkening of the cell, would yield a loud sound, heard throughout the hall. As regards the numerous practical applications of selenium, the selenium photometer, serving to measure luminous intensities, and the electric telephotographic apparatus designed by Prof. Korn for the transmission of handwriting, pictures and photographs, were discussed at some length.

Selenium ignition devices, lighting automatically gas or electric lamps at the fall of night and extinguishing them at daybreak, were shown, and the application of selenium cells to wireless (optical) telephony was finally described in detail. In connection with the latest experiments made by the author between Berlin and Grünau, a transmission of language, by means of rays given off from a projector, was secured over a distance as high as 15 kilometers (9.31 miles). The first experiments made in this direction outside of a laboratory were Herr Ruhmer's well-known Wannsee experiments.

Electrolytic Iron

ELECTROLYTIC iron was described in a paper by Charles F. Burgess and Carl Hambuechen recently read before the American Electrochemical Society at Washington, D. C. The electrolyte used in the process which is employed by the authors consists of ferrous and ammonium sulphates; the current density at the cathode is 6 to 10 amperes per square foot of cathode surface, and at the anode slightly less; the e. m. f. for each cell is slightly under one volt; the temperature of electrolyte is about 30 degrees C.; the anodes consist of ordinary grades of wrought iron and steel; the starting sheets for the cathodes are of thin sheet iron previously cleaned of rust and steel.

At the end of four weeks the cathode reaches an average thickness of about three-quarters of an inch, and the surface is so rough and nodular that it is not considered advisable to carry the deposition further.

The current efficiency of deposition is very closely 100 per cent.; that is, there is a deposition of about one gram per ampere hour. The e. m. f. being one volt, gives about 22 pounds of iron per kilowatt hour.

A run of two months' duration was made to determine the extent of the deterioration of the electrolyte, resulting in the conclusion that the solution can be kept in good working condition with little trouble or expense. It would appear, therefore, that the cost of refining, aside from fixed charges on plant, and with power at $30 per kilowatt year, would be under one-half per cent. per pound of iron, thus placing it not greatly in excess of the cost of refining copper.

Even with these figures realized, whether or not electrolytic iron can be profitably produced depends upon the uses which can be made of the refined metal. These in turn depend upon its properties, the most striking of which is its purity, analyses showing it to be in excess of 99.9 per cent. Not a trace of carbon was detected, and silicon, manganese and other impurities commonly found in iron appear to be absent. The only impurity which has been detected is hydrogen, which is present in appreciable quantities in the metal as taken from the electrolytic tanks.

The hydrogen can be driven off almost completely, if not entirely, by heating to a white heat, the evolution comencing at a temperature below 100 degrees C., and becoming rapid at a temperature below a red heat. The metal containing the hydrogen is so hard that it can be filed or sawed only with difficulty, and is so brittle that it is readily shattered by a sharp blow from a hammer. After the expulsion of the gas it becomes softer, and after having been raised to a welding temperature it assumes properties of malleability and toughness similar to those of Swedish iron.

The iron, when heated in a forge fire, can be readily welded and forged into any desired shape, and various test samples were made in this way. During such working, however, impurities are introduced, analyses invariably showing the presence of a very small percentage of carbon. The cathodes, three-fourths of an inch in thickness, have a surface so rough that they cannot be rolled satisfactorily into sheets, though it is possible that improvements can yet be made in this respect which will enable smooth surfaces to be obtained. The deposit adheres so loosely to the starting sheets that it can be removed readily.

Steam Turbines Using Exhaust Steam

ONE of the most interesting and promising applications of steam turbines, mentioned by Professor Rateau in a recent "Steam Turbine" paper before the Institution of Mechanical Engineers, is found in their use of low-pressure steam—exhaust steam, in fact, from engines working intermittently. This class of engines includes hoisting engines, for example, rolling mill engines and others which ordinarily exhaust into the air. Professor Rateau has given special attention to the problem of the employment of such waste steam and has obtained satisfactory results by means of his regenerative steam accumulator combined with turbines at low pressure, which are themselves coupled directly to dynamos, centrifugal pump fans.

The regenerative accumulator, which is intended to regulate the intermittent flow of steam before it passes to the turbine, consists essentially of a vessel containing solid and liquid materials which play the part of a fly-wheel for heat. The steam collects and is condensed as it arrives in large quantities in the apparatus, and is again vaporized during the time when the exhaust of the principal engine diminishes or ceases. The necessary variations for condensation and regeneration of the steam correspond to fluctuations in pressure in the accumulator, this pressure rising when the apparatus is being filled and falling when it is discharging into the turbine.

Water which has a very high calorific capacity has been used as a heat fly-wheel; but in order to rapidly communicate to a liquid mass a considerable quantity of heat corresponding to the latent heat of steam to be condensed it becomes necessary, owing to the poor conductivity of water, either to arrange it in thin layers or to cause a rapid circulation in order to increase the surface of contact between the steam and the water itself.

The first accumulator designed by Professor Rateau had flat cast-iron trays in which water was contained in shallow vessels arranged one above the other. A later form of accumulator contained only water, in which a rapid circulation was produced by the

injection of steam into the body of the liquid itself. The low-pressure turbine, led by the regular flow which comes from the accumulator, and working, for example, between an admission pressure of 15 pounds per square inch and a vacuum at the condenser of 27 inches of mercury (back pressure of 1.6 pounds), can furnish an electric H. P. for about 31 pounds of steam per hour.

In a moderate-sized pit, consuming 13,000 pounds of steam per hour, it is therefore possible to economize under these conditions about 350 electric H. P. In steel works, where reversing steam engines are employed, consuming about 45,000 pounds of steam per hour, it will be easy to develop, by means of accumulators and turbines, an extra output of over 1100 electric H. P. It is desirable to mention that the prime movers are in no way injuriously affected in their working by the presence of the accumulator and turbines. This method was applied for the first time at Bruay, and the installation has worked most satisfactorily since August, 1902, when it was first put into use. The exhaust steam from a winding engine is first of all treated by an accumulator with cast-iron trays, and then passes to a low-pressure turbine of 300 H. P., which itself drives two dynamos keyed upon the same shaft. A particular feature of this type of installation is a so-called "automatic expander," which comes into use when the winding engine is not giving sufficient steam, and also when this engine is not working. This apparatus permits the admission to the turbine of live steam which is passed from the boilers through reducing valves, and can be adjusted by means of a spring, and comes into use as soon as the pressure falls below a predetermined point.

Electric Power Plant Auxiliaries

THE question of auxiliary plants, says Dr. Louis Bell in the just issued Electric Power Number of "Cassier's Magazine," is one which in modern transmissions assumes no little importance, and is the source of many worries. Auxiliaries may be required for three quite distinct purposes, each of which points at special directions of development. First, an auxiliary plant may be required purely for use in emergencies to carry more or less of the load in case of premeditated repairs to the main line plant or in the sub-station. Second, it may be required to help the plant over the peak of the load now and then, as well as for the former purpose. Third, it may be installed to assume part of the normal load at certain seasons of the year. In each case it is available to a certain extent in the event of an accident to the system.

The auxiliary plant of the first class is established for purely temporary use as a convenience in the ordinary contingencies that arise in every hydraulic plant. It is not intended to assume any considerable part of the load, but to go into use at times when the load is normally light, as during a part of Sunday or during the very early morning before the motor load comes on.

It happens now and then that some repairs must be executed which cannot be put through without a temporary shut-down, the time for which can be chosen beforehand. A comparatively small auxiliary, perhaps not more than 10 or 15 per cent. of the full load capacity of the system, will answer admirably for this simple purpose, its proper size being determined by the characteristics of the load. Clean and simple apparatus will answer the purpose here, for in such temporary use the matter of operating is secondary. A small steam plant at or near a sub-station is the simplest way out of the difficulty in many cases, although there is much to be said in favor of a storage battery and reversible rotary, particularly if the plant is hard pushed at times of maximum load.

The storage battery has, during the last few years, passed from a condition of doubt and uncertainty into clear recognition as a valuable adjunct in central station operation. If a transmission plant has a bad peak in its load line a battery can be put to an extremely good use in furnishing both an auxiliary in case of needed repairs and a source of additional power during the peak. It is far better suited to this use than to assume merely the function of an occasional auxiliary, or that of a reserve plant during periods of low water or the like. The first cost of the battery is rather high, and to keep it in first-class order it should be regularly used. If the conditions of the load demand, therefore, a very large use of the auxiliary, or very infrequent use, or both, the battery works somewhat at a disadvantage.

When, on the other hand, the chief use of an auxiliary plant is to deal with periods when a transmission plant is suffering from low or high water, a steam plant becomes a necessity, unless local conditions are such as to give the big gas engine an advantage over steam.

Hydraulic plants vary greatly in their need for this kind of assistance. In some instances the serious shortage covers only a few days in each year, and the lesser shortages can easily be covered by storage. In other cases there may be a month or so of moderately low water during which help is needed. Again, some plants suffer only during a few days of flood, which backs up the water and reduces the working head. Each case has to be treated on its merits, and there is a gradual passage of the conditions toward those in which more or less auxiliary power is needed most of the time. Such mixed power plants are rather in a class by themselves, and a volume might be devoted to their development.

European Telephone Development

TELEPHONE development in European countries has been along lines entirely foreign to those followed in America. According to "The American Telephone Journal," the reason for this is somewhat obscure, because in almost every other industry, the general design of apparatus differs in no material way from that employed in this country. An illustration in point is the hand microphone; although it has been exploited in America for upwards of twelve years, it has not become popular, whereas in European countries it might be taken as a standard of design. In France the old cumbersome two-receiver telephone is still in use and in some cases developments of the carbon pencil microphone are still used.

In general, European apparatus is much more cumbersome than the American manufacture. The reason for this is perhaps the desire to make a most substantial piece of apparatus, and consequently sacrifice looks for strength. Recent development, however, tends to be along lines similar to those followed in the States, and in many instances a remarkably fine instrument has been devised which embodies the substantial qualities of the old-style instrument, together with the simplicity of design so noticeable in American apparatus.

Particular thought has been given to the protection of instruments from contact with dangerous current. In America the only protection thought necessary has been that provided by lightning arresters, which are supposed to open or ground the circuit in case it becomes charged with a potential foreign to that which it is supposed to operate upon. European manufacturers, however, seem to lay more stress upon the desirability of making the instruments themselves of such a construction that even if for-

eign currents were to enter into their mechanism, should a person be using one, he would be in no danger of injury from a shock.

With this view in fact some German telephone instruments have recently been placed upon the market which are built upon lines quite foreign to American practice. It has been the object of the design to produce an instrument in which there are no metal parts whatsoever that can by any possibility come into contact with the subscriber. The theory of this provision rests upon the idea of the possible exposure of the conversationalist to a shock from a thunderstorm or a cross in the wire while in the act of using the instrument. Each sub-station is provided with a peculiarly designed high-tension fuse capable of protecting the circuits against 3000, 5000, or even 10,000 volts, as the case may be. To guard against sneak currents, a sensitive carbon protector is provided, and then the line wires are brought through the back of the set so that there are no binding posts exposed.

The crank for the magneto is built of hard rubber and to the receiver two listening tubes are attached, which are further insulated by rubber tubes. In America there have been so few cases of injury to subscribers while using sub-station instruments that the query at once arises as to whether in the complication here described the game is worth the candle.

Electric and Compressed Air Locomotives for Mines

IN a paper read by B. S. Randolph at a recent meeting in London of the Institution of Mining Engineers, the author declared his belief that the advisability of either form of haulage is entirely a question of the conditions which obtain in each case. The pneumatic locomotive, being larger, is not so well adapted for low seams as the electric locomotive, except when safety in the presence of fire-damp may be held to counterbalance its disadvantages. Small pneumatic locomotives serve well for bringing mine cars from the different working places to main roads—work which cannot be done by electricity, owing to wiring difficulties.

The author considered that the transmission of electricity, although cheaper for short distances, is not so for greater distances when compared with compressed air. He remarked, too, that an electric plant must be proportioned solely to meet the maximum demand, while the pneumatic plant is proportioned to meet the average demand.

Mr. Randolph has compared the cost of the two plants in successful operation, the maximum haul in each case being about 8000 feet. The compressed air plant operated two main hauling locomotives, each weighing 30,000 pounds, and five gathering locomotives, each weighing 8000 pounds; it cost $34,320. The electric plant of four locomotives, each weighing 26,000 pounds, cost $32,490. Had, however, the compressed air plant consisted of four larger locomotives, instead of so many smaller ones, the cost would have been $29,460.

In the discussion following the reading of the paper the opinion was expressed that compressed air had not made much progress because, unlike electricity, it lacked interested advocates; from a point of safety it had a great advantage over electricity, and and very likely it could be worked quite as economically. The easy working of electric locomotives was referred to, and the use of electricity to compress air underground for use in the mine was also commented on favorably.

Electric Winding Engines

IN the anthracite mines of Pennsylvania, according to "The Engineering and Mining Journal," there are over 60 electric hoists in use on inside slopes. These hoists usually have a single drum driven by a friction clutch, double reduction gears and a series motor. On steep slopes two motors are used. Some double motor hoists are used with series parallel control, the motors working in series for slow pulling around curves and in multiple for high speeds. Electric hoists are also in use at many western camps, notably Cripple Creek, where fuel is dear and electricity may be had from the lines of large power companies. The great majority of these hoists are of small size and do not run at high speeds. So far as we know no mine in this country is using an electric hoist for heavy loads from deep shafts.

Economy in steam consumption at Pennsylvania mines has received little attention, until within the past ten years, and the enormous losses from long, poorly protected mains have been disregarded. Now that steam losses are receiving proper consideration, the economies of central power stations distributing electricity are under discussion. There has been much conservatism, perhaps too much, in the mechanical engineering departments of the great anthracite mining companies, but changes are certainly impending.

Hitherto the accepted equipment for hoisting at the main shaft has been a simple engine, with or without Corliss valves, directly connected to the drum and exhausting into the air. The ends sought apparently have been strength and simplicity. The engineer is held responsible for accidents; overwinding devices are rarely used, and detaching hooks are practically prohibited by the wording of the State law. The failure to use electricity more extensively has been due not only to the conservatism of engineers and general managers, but to the opposition of the State mine inspector, so that it is not altogether strange that there has been a general hesitancy to forsake the old and tried for the new but promising.

In Europe, however, nearly all the larger manufacturers of electric machinery have installed main hoisting engines driven by electricity, and there is a pronounced tendency in favor of electrical gear in all the new work. Most of the installations use alternating, three-phase current, the motors being direct-connected or driving through gearing; some continuous current motors are at work, generally for light loads and short lifts.

Magnetic Alloys of Manganese

AN interesting discovery, made by Dr. Fr. Heusler, of the Isabellenhütte, Dillenburg, is mentioned in the London "Electrical Review." While experimenting with an alloy of manganese and tin, Dr. Heusler noticed that it was strongly attracted by an accidentally magnetized tool. On melting the alloy with an equal weight of copper, he found the resulting combination also distinctly magnetic. He also succeeded in making magnetic alloys by adding tin to commercial copper manganese containing only 1.2 per cent. of iron, this copper-manganese itself being perfectly non-magnetic. On making experiments with other metals, it was found that arsenic, antimony and bismuth each had effects similar to tin, but aluminium gave the best results of all. With the help of Messrs. Richarz, Starck and Haupt, a thorough investigation of the whole subject has been carried out, and many interesting discoveries have been made.

It has been found that the most magnetic alloys are those in which the manganese and aluminium are present in direct proportion to their atomic weights.

The transformation temperatures of

the alloys—the points at which they lose their magnetism—are comparatively low. An alloy containing 16 per cent. Mn and 8 per cent. Al becomes non-magnetic at 165° C., and remains so if plunged into cold water; it becomes magnetic again, however, if kept at a temperature of 110° C. for a day or two. By adding small quantities of lead the transformation points may be brought down to still lower temperatures—60° C.

In connection with these curious results, further says the "Electrical Review," it should be mentioned that manganese had already some claim to be classed as a magnetic metal, for it is well known that some of its salts are almost as magnetic as those of iron. Twelve years ago T. W. Hogg exhibited before the British Association two pieces of alloy, one of which contained 14.8 per cent. of iron, 75.4 per cent. of manganese, 5.6 per cent. of carbon, 3.1 per cent. of aluminium and 0.9 per cent. of silicon. Although the proportion of iron was not large, the alloy was strongly attracted by a magnet. The very magnetic iron-aluminium alloys shown not long ago by Prof. Barrett may possibly be a further exemplification of the action of aluminium in bringing out or increasing magnetic properties.

The remarkably low temperatures at which the new alloys lose their magnetic properties open up possibilities of practical application in various directions. For example, they might be used for fire alarms, closing or opening an electric circuit by the release of an armature when the transformation temperature was attained. Or the device invented by E. Berliner, in 1885, for generating electricity direct from heat by heating and cooling iron armatures in a magnetic field, might be realized, though this probably is too sanguine an anticipation.

The new alloys are strong, not difficult to work, and are not easily oxidized.

Railway Auto-Cars

MANY of the railroads in the United States have much revenue adjacent to their tracks, says "The Railroad Gazette," which could be developed by providing needed traveling facilities between railroad stations and outlying districts. The truth of this statement has been proved by the experiences of steam roads which have been benefited by interurban electric roads acting as feeders. In the early days of interurban electric competition, the steam roads sought to win back local traffic by cutting rates, but this procedure was soon found to be ineffective. Most steam and road managers now realize, or should realize, that the most attractive features of the electric road are frequent service, high speed and accessibility to the passenger, and unless the steam road can offer these same advantages, the bulk of local traffic will continue to go to the interurban roads which use electric motor cars. The only hope for purely local steam roads is in electrification. Steam roads doing mainly through business have nothing to fear from local electric roads for the reasons before mentioned.

A good many attempts have been made by steam roads to duplicate the service of electric roads without the necessity of a large investment in electrical apparatus, overhead or third-rail construction, motor cars, etc. New and powerful steam locomotives have been tried and found wanting, as for example, on the Great Eastern of England. On a great many roads, especially in the western part of this country, there are branch lines on which passenger trains cannot be operated with profit. The high wages now paid enginemen and trainmen and the necessity of employing two enginemen and two or three trainmen even on a short train, makes the service too expensive. The alternative of the railroads has been either to take off the service entirely or to run a mixed service, and the result is that the communities are grumbling and asking for electric roads.

With the above considerations in view, it is quite evident, says the "Railroad Gazette," that there is a field for a rail auto-car built on the principle of an automobile and run by steam or gasoline. The term "auto-car" is used to designate cars which generate their own power, from motor cars, which get power from overhead or third-rail conductors. From an operating point of view, the use of such cars would solve many troublesome problems, but so far, difficulties have been met in designing a car suitable for the service required. Auto-cars will probably never be designed which will be capable of competing with the electric interurban car, for at least 250 horse-power per car is required in order to get high acceleration and speed and at the same time have a little reserve power for climbing grades. In fact, most interurban electric cars have 300 horse-power or more in electric motors, and some have as high as 600 horse-power. The auto-cars so far designed have not had motors exceeding 100 horse-power.

The auto-car used on the North Eastern Railway in Great Britain has an 80 horse-power gasoline motor driving a dynamo. The current generated is used in motors on the trucks. The gasoline motor and dynamo take up about one-fifth the total length of the car and nearly all the width of the car, so that a larger motor could not well be used. If steam is used as motive power, the space occupied by the boiler and coal and water is large. Steam cars are used by the Great Western, London & South Western, Taff Vale and other foreign roads. They have also been tried in this country. Tests on the London & South Western car, which seats 46 passengers, show that the maximum speed of 25½ miles an hour is reached 55 seconds after starting.

It is quite possible, further says the "Railroad Gazette," that the development of the automobile will point the way to a rail auto-car which will work smoothly and economically at moderate speed. High speed and acceleration such as is possible by electric motor cars will undoubtedly never be possible with auto-cars. But there is a field for the auto-car even in its present state of perfection. There are many places where there are good-sized communities 10 or 15 miles from the nearest station of a steam road. It is this sort of revenue adjacent to the tracks that was referred to in the opening sentence of this article. By building short branch lines of light construction into such communities and running auto-cars at intervals to connect with main line trains enough traffic could no doubt be obtained to pay for the investment. In such cases the auto-car would take the place of the farmer's horse and wagon.

Doing Business with China

IN a recent report the British Consul-General at Hankau says:

"It appears that the Germans and the Belgians have secured all the contracts awarded by the Chinese authorities for supplying machinery to the arsenals, mines and iron works. The English firms are themselves to blame for thus remaining empty-handed. In this as in numerous other cases it is owing to their indolence that their competitors carry off the prizes.

Occasionally English firms send price lists to this consulate requesting their transmittal to suitable parties. But they are not aware of the fact that the Chinese authorities prefer dealing directly with the contractor or manufacturer in person. When it is desired to obtain government contracts here, then properly accredited

representatives must personally negotiate with the chiefs of the governmental bureaus and give to the latter full information on all points concerning British productions."

The remarks of this British consul apply with equal force to American exporting interests.

A Labor Item

THE New York Rapid Transit Subway is making votes for the coming fall election—for Tammany Hall. The walls require much smoothing before the painters can put on the finishing touches. A small army of men is needed for this, and they are drawn from Tammany's idle constituents who receive therefor the good wage of $2.50 a day.

According to the New York "Sun," the voters who have been put to work know a good thing and are not going to let the job peter out this side of Christmas if they can help themselves. One old Irishman, notorious as a "soldier," was prodded the other day by one of the foremen.

"Here you," said the foreman, "git a move on! I've been watching you for half an hour, an' that young fellow alongside of you has done three times as much work as you have."

"Sure, Oi've been tellin' the damn fool all day about it, but he won't shtop," retorted the veteran.

The Control of Interurban Traffic

IT was announced a few days ago that the New York Central had secured control of the Syracuse Rapid Transit and the Utica & Mohawk Valley Companies, operating electric lines which compete for the short-haul passenger traffic in the territory served by the steam railroad in northern New York State.

According to "The Railroad Gazette," this is the most important step in meeting trolley competition which has been made since the New York, New Haven & Hartford took over the electric lines in New Haven, as a definite base from which ultimately to maintain an electric short-haul service of its own and to prevent further paralleling of the main and branch lines in this district.

This method of controlling trolley competition by setting a rogue to catch a rogue is undoubtedly the best way of taking care of the short-haul business in the vicinity of large cities, in view of the tremendous inroads which the electric lines have made in this territory within the last few years.

The Utica & Mohawk Valley line, which constitutes part of the present purchase, runs from Rome to Little Falls, 38 miles, through the city of Utica, with a branch to Clinton 9 miles long. The company almost at the outset picked up an interurban business of some $30,000 a month, entirely independent of the heavy traffic in the city of Utica, and an efficient express service is maintained in connection with the passenger traffic.

It seems quite evident, says "The Railroad Gazette," that the steam road will be better served by having the Utica & Mohawk Valley as an ally instead of as a competitor, for these lines formed the nucleus of what was likely soon to become a very serious competition indeed.

At Syracuse the problem which the company has to face is the prevention of the establishment of a competitive paralleling electric line to Rochester. The country is well adapted for the interurban business, and it seems obvious that it would, in the near future, have been a troublesome locality if the steam road had not taken the trolley business into its own hands.

Control of the interurban lines in competitive territory is so reasonable and so easy a solution of the problem, that even at this time, when only the beginnings have been made, it seems remarkable that the chance has been so long neglected by the steam roads. A few years ago it would have been far easier and far cheaper than at present to secure either the properties as they then existed, or the franchises; a few years hence it will be far harder and far more expensive than it is now.

The New Haven road and the New York Central are in the van of a movement which must shortly come in the many localities where the electric road is obviously the best agent for handling short-haul traffic. The steam roads now have a chance to build up an excellent collateral source of income and to establish at the same time an ally and a defense. If they neglect to do so they are sure to lose much, both of old business and of new profit.

The interurban people in the last few years have been carrying on a most valuable object lesson in the development of suburban territory, and with that development goes also a suggestion of the way city tracks and terminals can be efficiently and economically cleared of the local passenger traffic, which is expensive to provide for and which blocks the way of the through traffic, the natural function of the steam road.

Machinery Hall, unlike the other buildings at the St. Louis World's Fair, is not closed in the evening.

Prospective Advances in the Use of Electricity

IN considering what the next advances will be in the use of electricity, Dr. C. P. Steinmetz writes as follows in the "Electric Power Number" of "Cassier's Magazine:"—

If we compare the efficiency realized in the production of light from electric energy, of perhaps 5 per cent. as a maximum, with the efficiency of producing mechanical energy in the electric motor, or electric energy from mechanical energy in the electric generator, where values of 90 per cent. to 97 per cent. are commonly realized, the present methods of electric lighting appear rather crude in their principle; it is really heat that we produce, and light appears almost as a mere by-product. While, therefore, no very essential advance in the efficiency of electric motors, generators, etc., is possible, electric lighting is still in its very beginning. The amount of light produced would still be low compared with the efficiency of the electric motor.

In this direction, then, an enormous advance in the use of electricity can be hoped for in the future. If the efficiency of production of light from electric energy could be raised only to the efficiency of the poorest electric motor on the market, electric light would sweep all other illuminants out of existence by its cheapness This is well realized by those in control of the electrical industry of to-day, and some years since many of the giant electrical manufacturing companies of this country and abroad established extensive laboratories for the investigation and study of improved methods of electric lighting. In the last years avenues of research have been opened and are being energetically pursued in these laboratories, which promise to replace the present indirect and inefficient methods of light production by a more direct transformation of electric energy into light, with a far higher efficiency.

A new method of automatic marking for musketry practice has been invented, says the "Army and Navy Gazette." Under the projected system an iron target, marked out in the usual way, is formed of separate pieces, and when a bullet strikes one of these it is forced back, and completes the circuit of an electric current. An indicator at the firing point then shows the result of the shot, and when the hit has been registered a button on the indicator is pressed, breaking the circuit, and causing the portion of the target hit to resume its original position.

THE ELECTRICAL AGE
Established 1883

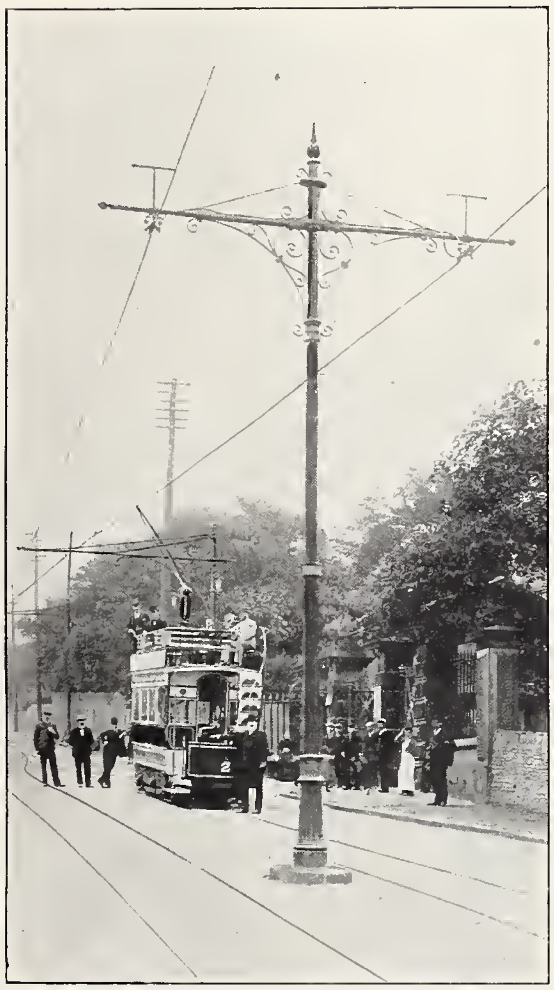
Volume XXXIII Number 2
$2.50 a year ; 25 cents a copy

New York, August, 1904

Entered at the P. O. as 2d-class matter.

Trolley Cars in Other Climes

BY ALEXANDER HUME FORD



A BIT OF OVERHEAD CONSTRUCTION AT BRADFORD, ENGLAND

It is not twenty years since the electric trolley car made its first appearance. Yet to-day it operates on every continent of the globe and in every climate. Electricity as a possible motive power on steam railway systems also has entered the first stages of practical adoption. Installations at New York, Baltimore, Paris and other great cities are either already in operation or in course of completion, so that passenger and even freight trains may reach their metropolitan terminals behind powerful electric locomotives.

In Manchuria, an American electric light system illuminates every station of the American-built Chinese Eastern Railway, while the project of using electric power over the entire line of the Trans-Siberian Railway, from Moscow to Vladivostok, is under serious consideration, the single line of track having proved a failure as a steam railway across so vast a territory, in which wood and coal are scarce. Russian engineers are now convinced that with the motive power changed to electricity, and generating stations placed 100 or 150 miles apart, greater speed than the present 16 miles an hour could be maintained, while heavier loads could be hauled at a great saving in fuel.

There is a project on foot to connect the Trans-Siberian Railway with the Canadian systems, using electricity as a motive power, and the British Great Northern Railway has long looked forward to the time when it can economically change from steam to electric power.

At one end of this projected "almost-around-the-world" electric railway route, Paris is extending its third-rail system farther and farther from the French capital toward Germany, where high-speed records are being made on electric railways that promise in time to stretch across the German Empire from the French to the Russian frontier.

At the other end of the much-talked-of "around-the-world-by-rail" route, several New England railroads have already made a start in the direction of discarding steam for electric locomotives or trolley cars. The New York-to-Paris railway may then become a reality, even before the accomplishment of the equally stupendous scheme for a Pan-American railway from the mouth of the St. Lawrence to Patagonia.

Engineers are even turning from steam to electricity to send heavy freight trains across country. In the Caucasus Mountains $10,000,000 of American capital have already been expended upon a railway, on which the Russians expect soon to displace the steam locomotive by utilizing the many available mountain streams to supply electric power. In Central Africa the builders of the Cape-to-Cairo Railway are making similar changes in their plans.

The young man just out of college can easily recall the interest caused by the construction in America of the first street-car line on which electricity was used as motive power; yet to-day there is scarcely a fair-sized town in the country without its system of trolley lines. These are being connected with one another to such an extent as to make it seem quite probable that the son of the man in college to-day may be able to travel around the world by trolley before he steps into his father's college shoes.

In America, Yankee enterprise and ingenuity are completing a connected trolley line from Boston to Washington. New York State farmers are being fed on promises of wonderful results from the water-power stored in the Adirondacks, when applied to electric traction with Albany as a central point. Niagara is made to send cars speeding back and forth between Niagara Falls and Buffalo; Cleveland and Chicago are extending trolley wires in every direction; a Western railway contemplates the adoption of electricity as motive power for its trains to the Pacific Coast; and in the State of Washington, when water-power is not to be had from mountain streams, efforts are made to harness the tides of the ocean.

In fact it has been proposed, somewhat over-enthusiastically, no doubt, to obtain motive power from the

AMERICAN EQUIPMENT ON THE ORLEANS RAILWAY ENTERING PARIS. ELECTRIC LOCOMOTIVES MEET TRAINS OUTSIDE OF PARIS AND BRING THEM TO THE STATION ON THE BANKS OF THE SEINE. NOTE THE GUARDED THIRD-RAIL CONSTRUCTION. THE INSTALLATION WAS MADE BY THE FRENCH THOMSON-HOUSTON COMPANY, OF PARIS

tides for a system of coast lines of electric railway along Puget Sound and to Alaska. A Denver company with a capitalization of $50,000,000 has already been organized to build a railway across British Columbia and Alaska to connect the railways of America with the Siberian system, and the use of electricity as a motive power is contemplated also in connection with this half-way-round-the-world railway project.

Almost tne first people to take up and adopt the trolley system of passenger transportation outside of America were the Japanese. The ferryboat at San Francisco or Seattle, to which you are whisked from your hotel by trolley, now lands the tourist in the realm of the Mikado at a point where discarded American bob-tailed street cars, supplied with electric motors, await the rush of passengers. In fact, within the last decade almost every important city of Japan has installed electric street railways, and now the abundant water-power of the mountainous little kingdom is being used to develop sufficient electric power to connect by trolley the hundreds of cities, towns and villages strung along the thousand miles of Japanese lowlands adjacent to the Pacific Coast.

Already the American trolley car has influenced Japanese pictorial art, the "bob-tail," with little Japs in flowing kimonas "cutting on behind," being equally as interesting and dainty, when treated by the Japanese artist, as is the national jinriksha. Nothing can exceed the delight of a Japanese family out for an afternoon's ride in the trolley car. Ten sen (5 cents) are the usual rates for a 'ricksha ride of a few blocks, and an hour's ride is more than many Japanese workmen could ever afford, so that the 5-sen fares on the trolley cars have proved a boon to millions in the chrysanthemum kingdom. One even rubs elbows jumping on and off the trolley cars with women, who, in Oriental countries, if not excluded from public view, are usually expected at least to walk and carry all the heavy burdens.

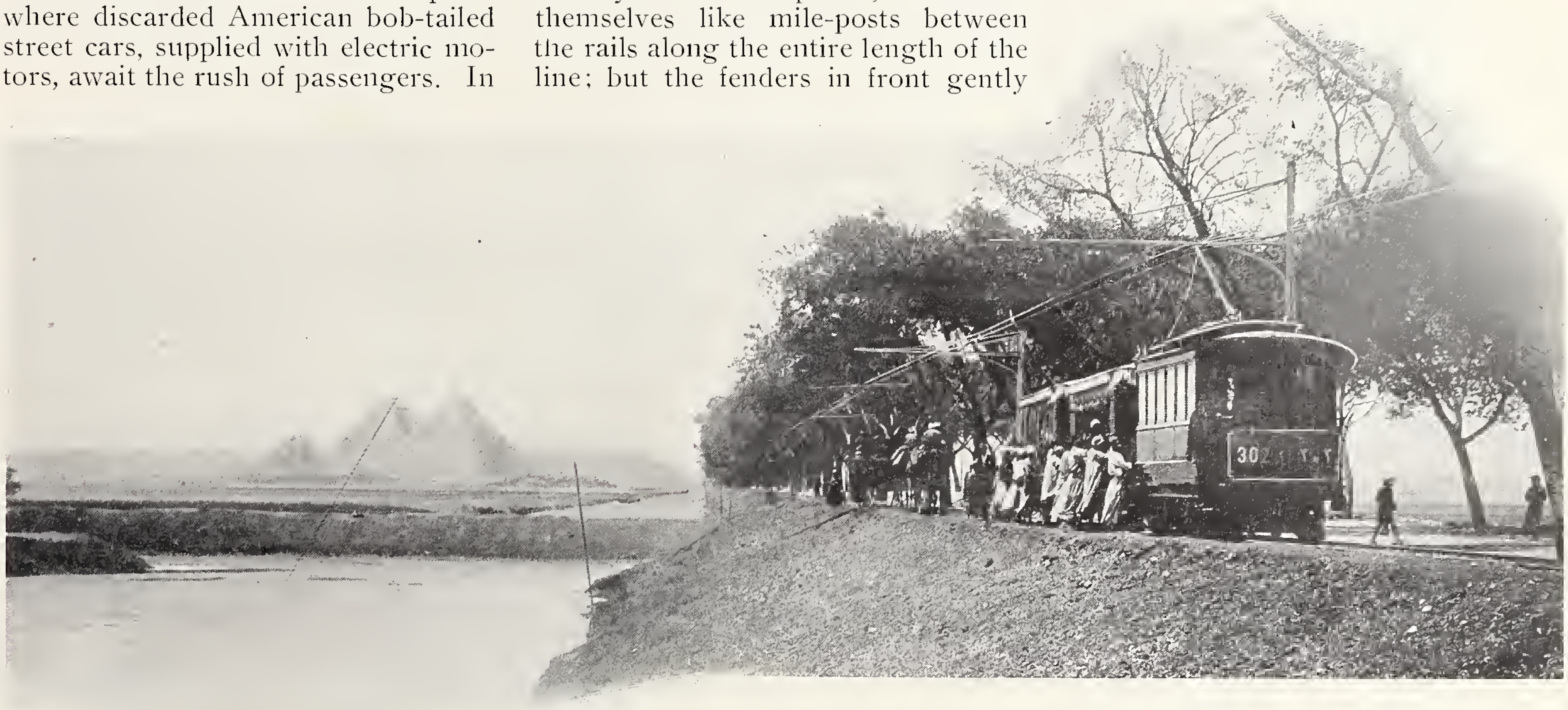
On the continent of Asia, also, the American trolley is having its civilizing effect, and Seoul, the exclusive capital of the Hermit kingdom, was, strange to say, the first city in Asia to permit American enterprise to lay tracks and string wires for an electric street railway. Opposition was not lacking from many "wise old men" of the ancient régime, who, when the railway was completed, stationed themselves like mile-posts between the rails along the entire length of the line; but the fenders in front gently gathered them in, and those who enjoyed the novelty of riding swiftly through the air did not hesitate to alight and pummel the obstructionists when necessity demanded.

At first there were many accidents at night, for the rails were just the height of the narrow blocks used by the Koreans to place under their necks when ready to sleep. Frequently the unwary "countryman come to town," who knew not where to lay his head for the night, placed it on the rails of the trolley line, and the first car that whizzed by neatly decapitated him. But all this was in the early days; now countrymen in Korea walk 100 miles or so to Seoul to spend their entire savings on riotous rides on the trolley car, and the company that built the line is reaping the reward of patience and merit.

The writer once rode on a hand-car pushed by Manchu coolies from the government storehouse of Vladivostok to the fortifications overlooking "The Golden Horn." This, the Siberians claim, is the first American tramway ever laid in Asia, but as it is a government line, for freight only, and the trolley system of Vladivostok is not yet completed, the palm of Asiatic enterprise must remain with the Korean city.

As already stated, every railway station in Manchuria is lighted from American dynamos. Dalny, previous to the present war between Russia and Japan, was to introduce the trolley. Shanghai and Peking are dallying with similar projects, and the native rulers of Mukden have asked for estimates from American electrical engineers. Manila has had rails laid for the American national carriage, and the Dutch have introduced the trolley in Java. Even south of the equator American trolley systems have spread the influence of American industry. It is but a very few years since New Zealand's first electric tramway was installed at Dunedin by an Anglo-American company to replace the old cable system. The new venture was somewhat in the nature of an experiment, but the American motors carried the British cars up the steepest hill-sides, and now every important city of New Zealand has its electric tramway system in operation, or in course of construction.

For just one-half the distance around the globe America has planted her trolley systems without interference or fear of rivalry, but once the Straits Settlements are crossed,

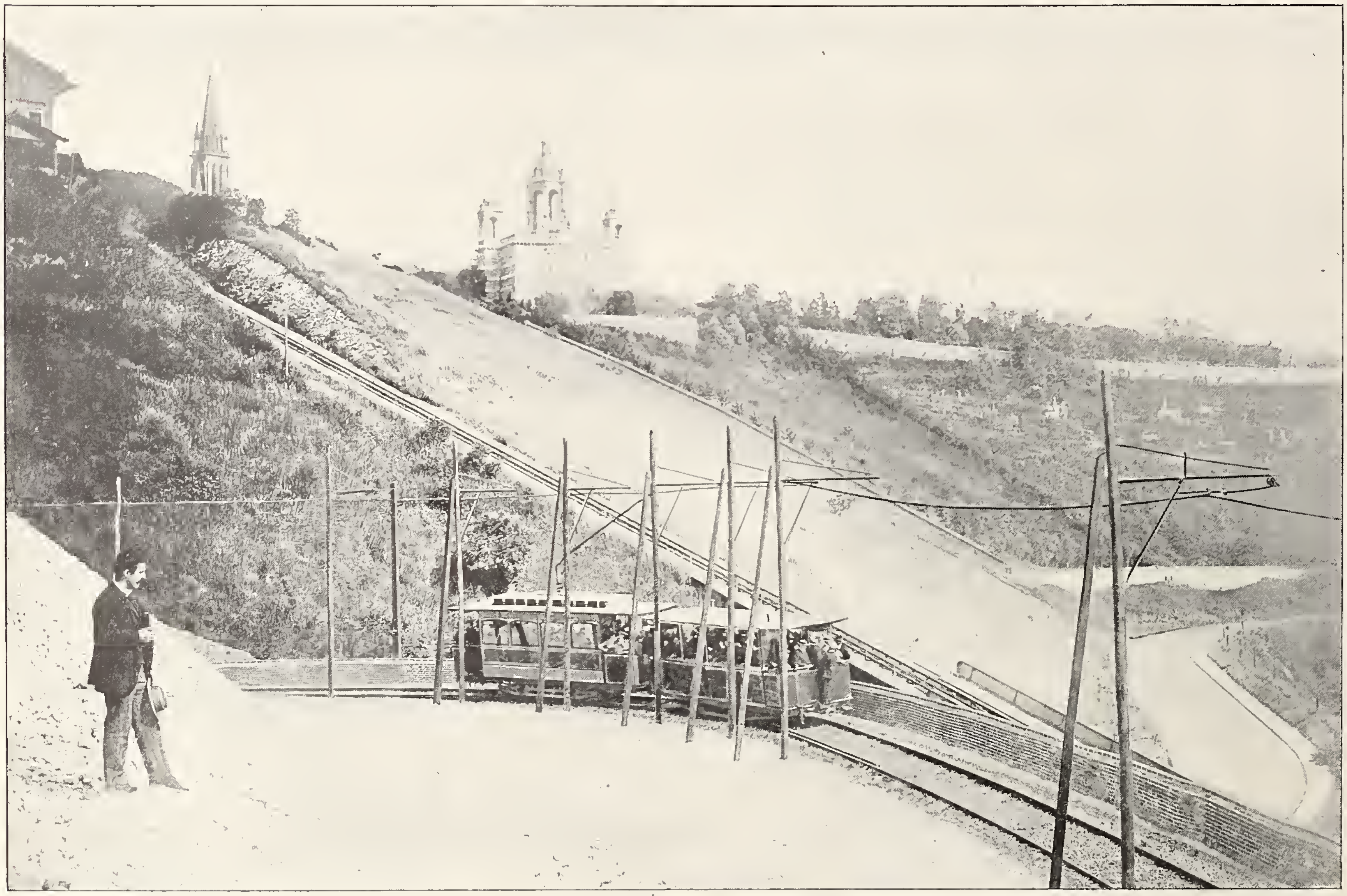


FROM THE NILE TO THE PYRAMIDS THE TOURIST NOW GOES BY TROLLEY

CAIRO IN EGYPT IS TYPICALLY AMERICAN IN THE MATTER OF ITS TROLLEY SERVICE

NEW ZEALAND TROLLEY CARS, AT DUNEDIN, WHERE THEY SUPERSEDED THE CABLE SYSTEM

THE TROLLEY AT NIJNI-NOVGOROD, RUSSIA



ROUNDING A CURVE ON THE ROUEN, FRANCE, TRAMWAYS

and the "trolley" becomes an "electric tramway," serious opposition is met with. The great electrical equipment works of Great Britain, France and Germany contest with the American builder for the privilege of laying new lines of electric railway in distant parts of the globe; but where the foreign works win, very often the motors are American, or made abroad by American companies using American tools and material in their manufacture. Thus, while an American c·mpany captures the streets of Bombay, the open cars of Madras are operated by a British electrical firm whose workshops are equipped with American machinery.

Th· influence of German competition begins to be felt at Cairo. From the banks of the Nile to the Pyramids a Berlin company has built an electric tramway over which American-made motors carry German cars. Much of the romance of a trip to the Pyramids has been destroyed; for nowadays, instead of riding out by donkey or on camel's back, the weary guide rides out in the same tram-car with his victims, and at the base of the Pyramids digs up from the sand before their eyes scarabæ and ancient idols, manufactured and discolored by machinery in Connecticut, whence they are shipped by the cask-load to the fakirs of Cairo, who use them to salt the sands of the desert and deceive American tourists into unwittingly patronizing the industries of their own country.

German competition is not the only kind against which the American has to fight in Egypt; there he may be said to be his own worst enemy, for while the trolley ride costs him but a few paltry piasters, the Connecticut scarabæ are seldom secured from the sandy bed for less than a large silver coin.

In South Africa the electric tram car is also making its appearance, even if somewhat tardily, Anglo-American, pure-American, and all-British firms contesting for the various contracts. Nor are all the electrical plums to be found in the cities. The Cape-to-Cairo Railway has reached the Victoria Falls of the Zambesi River, the most stupendous cataract in the world and one that, it is hoped, will supply sufficient power to operate motor cars many miles in either direction, north and south, from the great African River.

In Algiers the French, of course, control the building of all electric tramways, and any American material finding its way into the construction of these North African systems must do so through the French Thomson-Houston Electric Com-

THE FIRST CAR ON THE OCCASION OF THE OPENING OF THE ELECTRIC STREET RAILWAY AT BRADFORD, ENGLAND. THE CARS ARE OF THE FAVORITE ENGLISH DOUBLE-DECK KIND WITH A LOWER RATE OF FARE FOR THE ROOF SEATS

A TYPICAL BRITISH TROLLEY CAR AT HULL. ANOTHER DOUBLE-DECK EXAMPLE. THE TROLLEY POLE IS MOUNTED ON A SPECIAL STAND WHICH RAISES IT ABOVE THE DANGER ZONE FOR ROOF PASSENGERS

IN HALIFAX, ENGLAND

pany,—an American corporation in Paris with extensive works just beyond the city limits of the gay French capital. But while American enterprise is excluded from French Africa, just across the Straits of Gibraltar in Spain, at Bilbao and other Spanish cities, the hum of the American trolley is heard, and in ancient Rome, too, the American car invades the sacred precincts of the Colosseum.

Doubtless before long the electric car will spin through the dreary streets of Jerusalem, as it does to-day along the sleepy quay of ancient Smyrna, while from Constantinople to Paris the electric tramway promises to soon modernize every town of importance.

Russia alone of the European countries is slow to adopt the electric tramway. One exists at Nijni Novgorod, but it is about as cheap, and far more comfortable, when two persons are traveling together for a short distance, to hire a "droshky." This is probably the only city in all the world where cabmen consistently cut prices to meet the fares charged by the street car companies.

The governor and city fathers of Moscow have discussed plans for a system of electric tramways for many years, but the archaic two-story horse cars still carry on the business of the town. The rapidity of a trolley car would seriously interfere with the religious devotions of the Russian peasants and workingmen who flock to Moscow. On every block in the Slav capital are churches or holy pictures, before which special reverence must be made. On the upper deck of the cars, which are always crowded, off comes every hat, rain or shine, and the humble Russian crosses himself thrice with great dignity. Even with the slow-going horse cars, it is a continuous performance that mystifies and astonishes the foreigner. What the result would be with clanging, whizzing trolley cars, dashing by at break-neck speed, it is hard to conjecture.

In St. Petersburg, also, the horse-car system still reigns supreme. A single track with occasional switches

runs down the Nevsky Prospect. Every half-hour three cars in single file jog along, and if you miss these, it is speedier to go the full length of St. Petersburg's main street than to wait for the next trio of cars. There are fewer holy pictures in St. Petersburg than in Moscow, and as the fare on the top of the tram cars is but a cent and a half, the roof is always crowded, and in wet weather the mujik contents himself with bowing only as he passes the larger churches. There was to have been a system of electric trams in St. Petersburg, and the Westinghouse Company prepared to erect electrical works in St. Petersburg for their equipment, but with the reactionary party now in control at the Russian capital it is difficult to say when the next progressive step will be taken.

THE TROLLEY LINE AT SEOUL, KOREA

The thorough-going Germans have built few electric tram systems at home, but their perfect and artistic workmanship has attracted world-wide attention, so that it is probable that the greatest mileage of German electric trams is beyond the borders of Germany itself. In fact, the German Emperor's policy of absolute State control of transportation companies has militated against the development of the trolley in Germany, —not that the Emperor is unmindful

THE FIRST ELECTRIC CARS, MAY 1, 1900, ON THE ST. JOHNS, NEW FOUNDLAND, STREET RAILWAY

of the advantages of rapid transit, however, for under his direction, experiments have been made on the electric railway between Berlin and Zossen that have resulted in an attainment of very high speed—140 miles an hour.

France struggles hard to keep pace with Great Britain and America on one hand and Germany on the other. By her laws abrogating all foreign patents unless, within two years after they are granted, the parent company establishes works in France, she has succeeded in compelling both the Westinghouse and the Thomson-Houston companies to locate machine shops near Paris, so that the electric tram-car systems of the French capital may be said to be practically American; in fact, the equipment installed prior to the late Paris Exposition was imported didectly from the United States. This is true also of the electric trams of Rouen and other French cities.

American street-car customs, however, have found no favor in the eyes of Frenchmen. When every seat in a Paris car is occupied no one else is allowed to enter. Sometimes a car is divided in two, the forward end being reserved for first-class passengers at double-fare rates. Where there are seats on the roof, the fares are 3 cents above and 6 cents below.

Thrifty Scotland is the one successful rival of France in the matter of cheap electric tram fares. After importing American talent and workmen to build the tramway system of Glasgow, the city council, which controls and operates the street railway systems for the benefit of the people, put in force a half-penny fare, and this example is being followed by other thrifty Scotch cities.

Previous to 1895, Great Britain, with but 30 miles of electric trams, was more than backward in the encouragement of American promoters who wished to gridiron the large British cities with the trolley. All manner of laws intended to insure the safety of the pedestrian have been passed, and it is only now that anything like enterprise is being exhibited in the way of British tramway construction. The Westinghouse Company, in its splendid shops near Manchester, is turning out every kind of equipment for electric trams. Already Hull, Bradford and other English cities have been supplied with electric motors from these Anglo-American works that are even reaching out across the water, for they have recently completed the installation of an electric tram system at St. Johns, in New Foundland, and another at Halifax, in Nova Scotia.

Why Electric Power Distribution Sometimes Fails

THE general fault of power transmission systems, says Dr. Louis Bell, in the Electric Power Number of "Cassier's Magazine," is lack of a proper appreciation of the conditions of regulation, and a singular lack of enterprise in dealing with this part of the work. On the other hand, there is no difficulty whatever in finding people who are willing to take all sorts of chances in the matter of voltage and line construction, which, above all other things, are the roots of success or failure in transmission plants.

Still another cause is the ever-present and always ultimately disastrous desire to patch up an old system at the least possible expense rather than to gain the advantage of a better one at some additional investment. The result is to stave off the evil day of reckoning for a little, but to leave the plant as a whole in a condition that later demands the services of the surgeon rather than the nurse.

Given a reliable hydraulic power wisely developed and a modern polyphase generating plant, and there is no reason why the service, even at the end of a long transmission line, should not be of the most unexceptionable quality in all respects. If the service is not good, somebody has blundered or has been negligent. Above all things else, a transmission system needs intelligent engineering at every step of its development from its inception on. It is extremely easy for an unskilled superintendent to perpetrate blunders that are both exasperating and costly.

Good service implies a continuous and adequate supply of energy delivered at a closely uniform voltage. The first mentioned requirement depends upon the continuity of the transmission line itself and upon the distributing system as well. In this particular the plant behaves like an ordinary central station plus a long line over which the whole energy is delivered. It need hardly be suggested that for this reason the line is the last place in which to take chances.

In order to economize in cost of conductors and their erection, there is a constant temptation to reduce the factor of safety, both in insulation and mechanical strength. Raise the voltage and lighten the conductor so that you can skimp on poles, seems to be the present watchword of the alleged economist. Safety requires that whatever innovations are adopted the factor of safety should not be reduced. It is of very little use to build an elaborate station and then to connect it with the distribution system by a line that is just on the ragged edge of practicability. One line built thoroughly well and thoroughly inspected is safer than two lines skinned in cost and left to themselves in inaccessible situations. Two first-class lines are better than one, but the one is far more reliable than two poor lines.

A Large Electromagnet for Surgical Purposes

ELECTROMAGNETS for attracting particles of iron or steel from the eye have been made use of extensively by physicians, but hitherto the magnets have not been of sufficient strength to draw the particles out if embedded deeply. Recently an electromagnet of unusual strength, and said to be the largest yet built for medical purposes, has been placed in the Bridgeport Hospital at Bridgeport, Conn. The core is said to weigh several hundred pounds and is over 4 feet high. A mile and a half of copper wire are used in the windings.

From its great weight it was undesirable to make it movable, and so it is placed in a vertical position, and the patient, standing near, rests his face on a brass support, the eye just clearing the point of the magnet. This point is removable so that it can be sterilized.

Electric Railway in Life-Saving Service

THE Lake Shore Electric Railway Company in Ohio has made arrangements to carry the life-saving crew to points of emergency along the lake, whenever necessary. Negotiations were concluded with the company for this purpose a short time ago. A complete outfit will be kept on a flat car at Lorain, and the car will be run out at the call of the life-saving station.

This road runs along close to the lake almost the entire distance to Toledo from Cleveland. At least it touches all the important points. The steam roads may be used to some extent also, where any point can be reached quicker and better in that way. Between Lorain and Sandusky, however, the electric road will be used almost entirely.

United States Consul B. S. Rairden, at Batavia, Java, says that magnetic iron sand has recently been discovered on the south coast of Java. The persons who made this discovery have obtained concessions from the Government and are ready to accept offers to exploit them.

Electric Locomotives

For Mining, Factory and Allied Uses

By J. F. GAIRNS

THE design of electric locomotives for mining and general industrial use has received considerable attention, particularly on the continent, during the last decade. As soon as the experimental days of electric traction were passed and the electric locomotive could be said to be a practical and safe machine, the immense advantages it possesses as compared with steam and compressed air locomotives were quickly realized. These advantages are the compactness of build, the obtaining of great power by means of a relatively small engine, the absence of a furnace and a boiler or reservoir, the simple arrangements necessary for the supply of current, and its peculiar adaptability for odd-and-end work. It is, therefore, not surprising that electric locomotives specially designed for work such as we are now considering are in use in large numbers with very satisfactory results, and in several instances are displacing the steam and compressed air locomotives previously in use.

It is true that there are disadvantages as well, and the use of electric locomotives in "fiery" collieries would be attended with danger, owing to risk of explosion through sparking or short-circuiting, though on this point authorities are widely divided and the case may be considered doubtful; but in other mines, in shunting yards, and about works and factories, the present position of the electric locomotive is a very strong one, and there are many hundreds of them in use at the present time doing good work and giving good commercial results as well as practical service. It is not possible, in this article, to exhaust the subject, and besides the actual locomotives to be described in this section, the writer possesses particulars of dozens of others; but an attempt will be made to indicate what is being done as thoroughly as space will allow.

The first installation of electric locomotives for use in mines—and this practically antedates any attempt to apply electric traction for other than tramway work—is due to the great electrical firm of Siemens & Halske, and was put down in the Oppel shaft of the Zaucheroda Collieries in Saxony, in 1883. The locomotive was mounted on two axles driven by gearing from a motor; it was 8 feet long, 2 feet $7\frac{1}{2}$ inches wide, and 5 feet high, and it worked on 22-inch gauge lines for a working length of about 3 furlongs. In practice it could deal with trains of fifteen tubs each, loaded with 9 cwt. of coal. Usually the locomotive pushed, not pulled, the train. In design, the locomotive was double-ended and the driver changed from one end to the other according to the direction of travel. After a short while, a second locomotive was provided for working another shaft, and then the electric traction equipment of the mine comprised the two locomo-

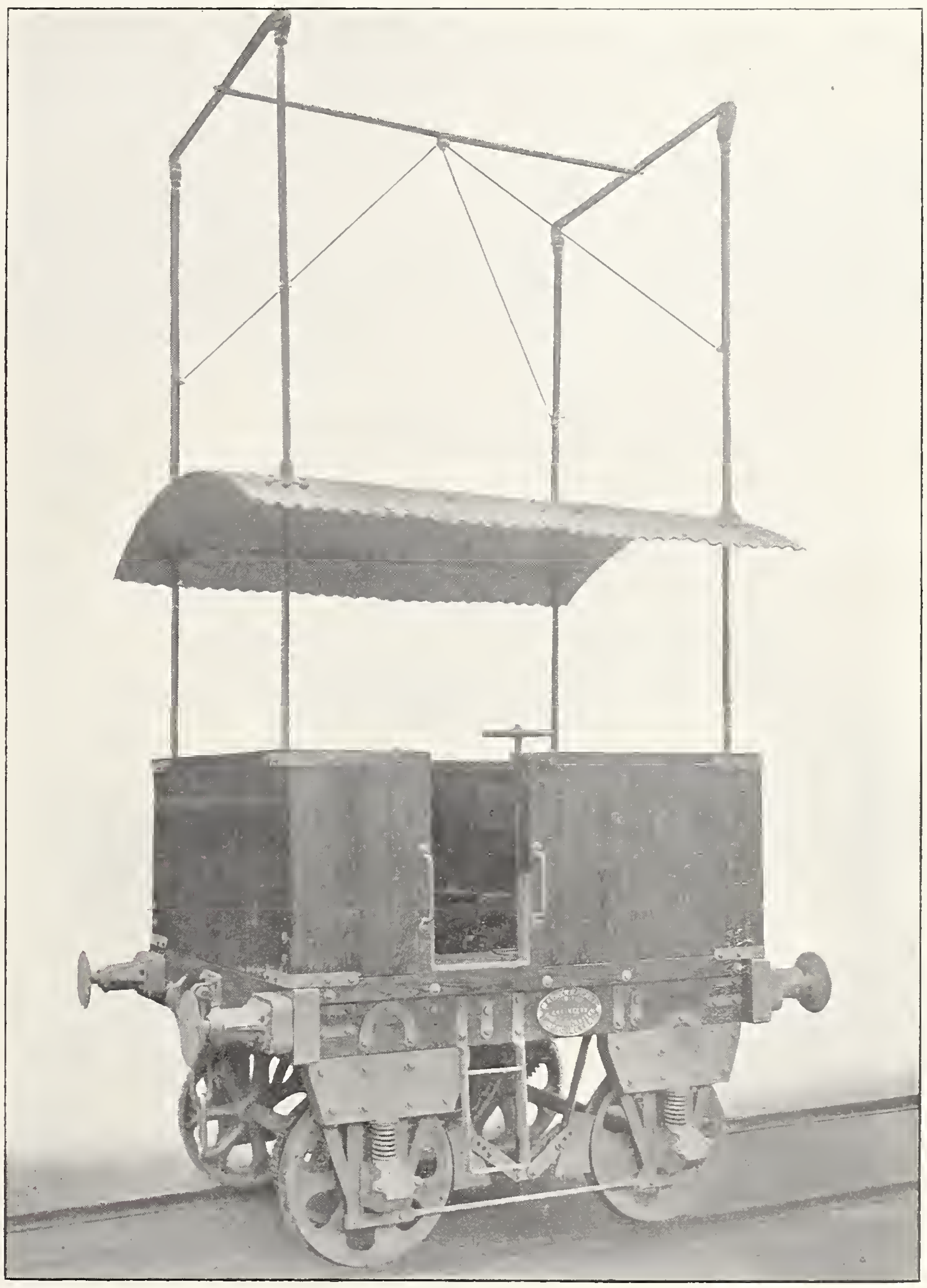


FIG. I.—A SHUNTING LOCOMOTIVE BUILT BY MESSRS. MATHER & PLATT, LTD., MANCHESTER, ENGLAND

tives and an electrically-driven haulage chain in a heavily graded part of the mine.

In 1883, electric locomotives were also adopted in the Consolidated Paulus and Hohenzollern Colliery at Beuthen, and in 1884, at New Stassfurt, both places being in Upper Silesia. Shortly after, the Aschenborn shaft of the Gottessengen mine in the same district was similarly equipped. At about the same time, the Allgemeine Elektricitaets Gesellschaft entered the field a competitor for the work, and equipped the Consolidated Konig and Laura mines in Upper Silesia.

Very few particulars of these locomotives are available now; but from the information in the writer's possession, in the Siemens & Halske locomotives just mentioned the motor was mounted longitudinally on the frame and drove by bevel gearing, through an inclined shaft, a spindle, which geared on either side with one of the running axles. Two overhead conductors of rail construction were used, contact roller sleds, on wheels, or, in some instances, contact sliding sleds, running on the conductors. The Allgemeine Elektricitaets Gesellschaft locomotives were somewhat similar, though they differed considerably in construction details.

Without going fully into history, these five cases of the installation of electric locomotives for mine work—none of the mines in question are "fiery"—mark the initial attempts to apply electric traction for displacing animal power in collieries and the like, and although in one or two cases the electrical locomotive equipment did not last, they represent early work on the part of the pioneer firm of Siemens & Halske, and also of the Allgemeine Elektricitaets Gesellschaft, which has given data and provided experience for further locomotive designs, which, as electrical engineering has developed, have given us the efficient mining and industrial locomotive of today.

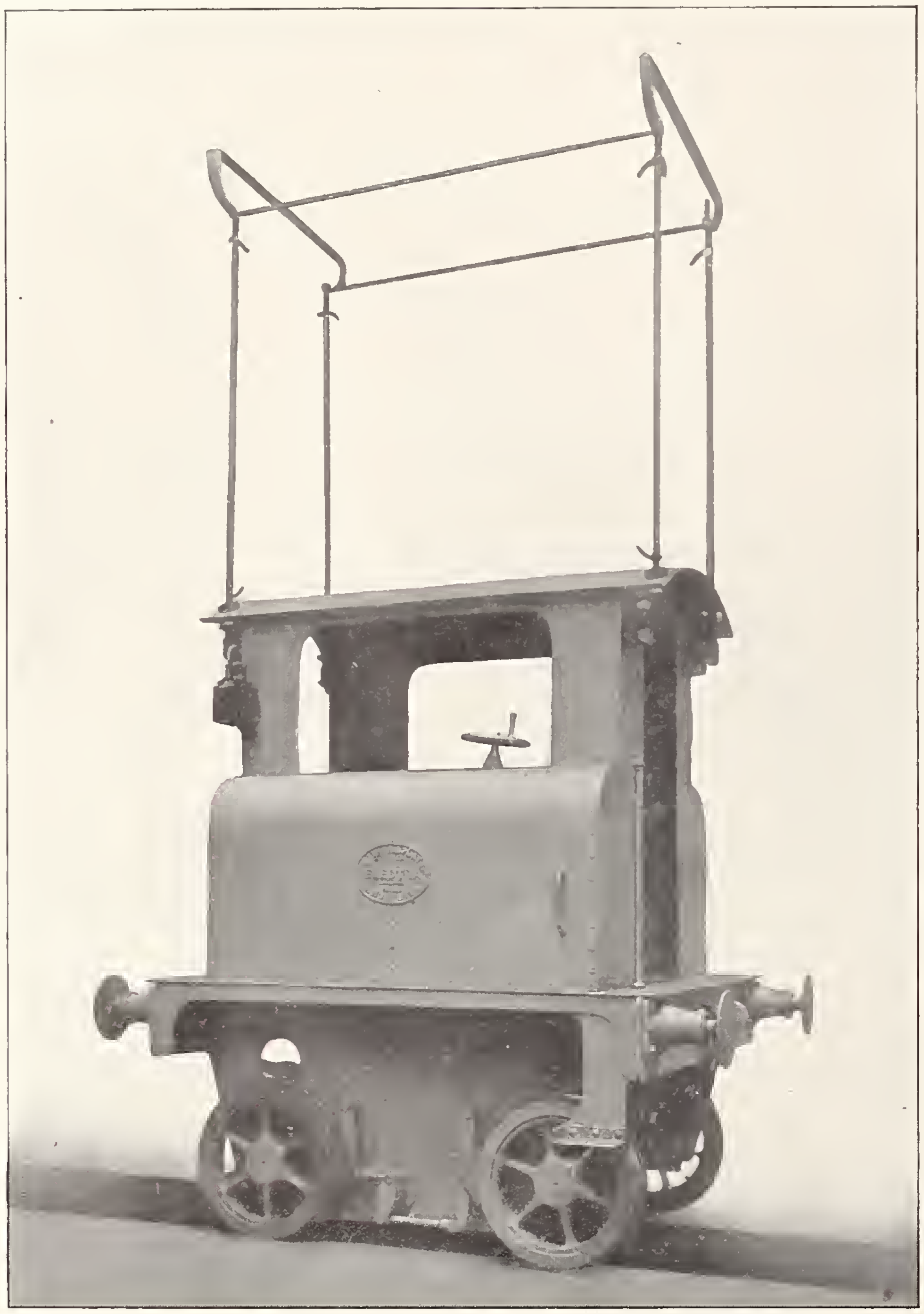


FIG. 2.—AN ELECTRIC SHUNTING LOCOMOTIVE BUILT BY MESSRS. MATHER & PLATT, LTD., MANCHESTER, ENGLAND

In Great Britain, the electric locomotive as an industrial machine has received little attention until recent years, and for mining work, locomotive power of any kind is hardly used at all, owing to the difference in the conditions there and on the Continent and in America; but an early experiment in electric locomotive traction at an English colliery is worthy of notice here.

In 1890, the General Electric Power and Traction Company installed an electric locomotive, working on a system designed by Messrs. Immisch & Walker, in the Wharncliffe Silkstone Colliery for working on an incline of about 1 to 9 and about 500 yards long. A fixed cable was fitted and a 10-horse-power electric motor on the locomotive hauled on the cable and so pulled tubs loaded to about 4 tons. Current was supplied by means of an overhead wire. The headway was 4 feet 3 inches only. This locomotive worked well for some time, and may be still in use. The locomotive and installation was fully described in Vol. CIV. of the Proceedings of the Institution of Civil Engineers of Great Britain. In America, the first electric mining locomotive was installed at the Erie Colliery in 1889.

It will now be well to consider a few actual examples of electric locomotives for mining and general factory and like service as built at the present time by the leading firms. Although Great Britain has done comparatively little work in this direction, there are a few firms who have produced electric locomotives for use about factories and in non-fiery mines, and by the courtesy of Messrs. Mather & Platt, Ltd., of the Salford Iron Works, three of their productions are illustrated here, one of which has not previously been described in the public press.

Fig. 1 illustrates a small locomotive built about ten years ago, and supplied to the textile machinery works of Messrs. Tweedle & Smalley, of Castleton. It is designed to draw a loaded wagon, not exceeding 20 tons weight, at a speed of about 2 miles an hour. It is used for shunting wagons on a siding connecting the boiler house and delivery stores of the textile machinery works with the main line. The current is supplied by overhead wires and returns through the rails, which are bonded with copper strips and rivets.

The locomotive somewhat resembles an ordinary goods wagon. It is fitted with coil-spring buffers of the standard height and centers, axle boxes and guides, and a hand screw brake with

wooden brake blocks bearing on the car wheels, which are 28 inches in diameter. The locomotive is roofed in with galvanized corrugated iron carried on wrought iron pillars. These continue through the roof and carry the collector-bars, which rub upon the conductor wire.

The driving motor is of the Manchester type, and is mounted on a cast iron bed plate which slides on cast iron brackets bolted to the framing of the car. The motor is fitted with a vulcanized fibre pinion with steel end plates of twenty-one teeth, the pinion gearing with a cut cast iron wheel of seventy-two teeth on the gudgeon shaft, on which is keyed a chain pinion of seven teeth, driving a chain wheel of twenty-two teeth, fitted upon one axle of the locomotive. A sand box is provided, and the car is fitted with a controlling switch, resistance box for starting and regulating the speed, and a reversing switch. The weight of the locomotive is a little over 3 tons.

The system of collectors on the locomotive lends itself particularly well to the requirements of this line, as there are many points, curves and crossings. The system consists of two wrought iron bars placed about 6 feet apart, one of which is always rubbing on the under surface of the overhead wire. Fig. 2 shows another locomotive built by this firm for use as

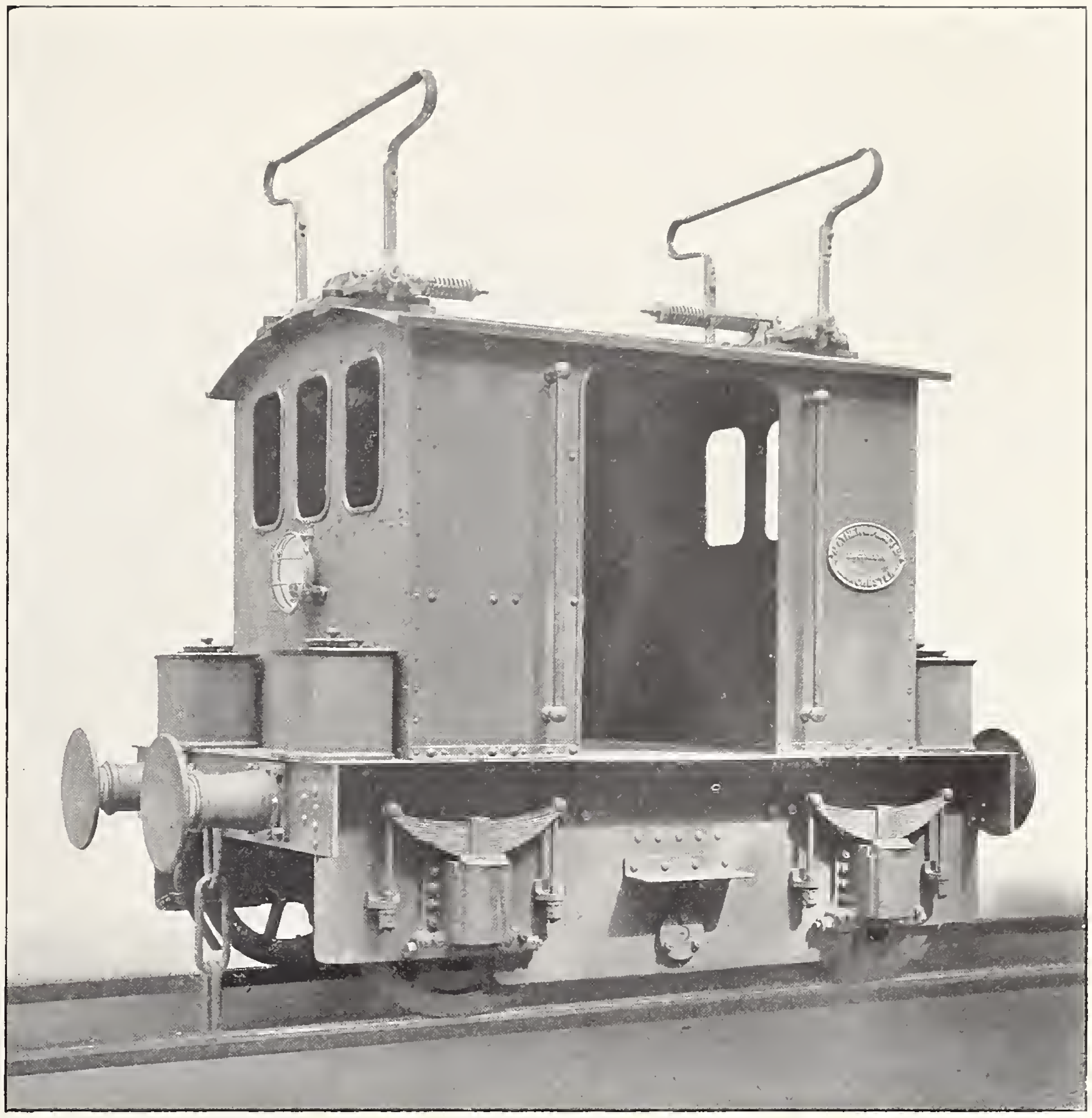


FIG. 3.—A MINE LOCOMOTIVE BUILT BY MESSRS. MATHER & PLATT, LTD.

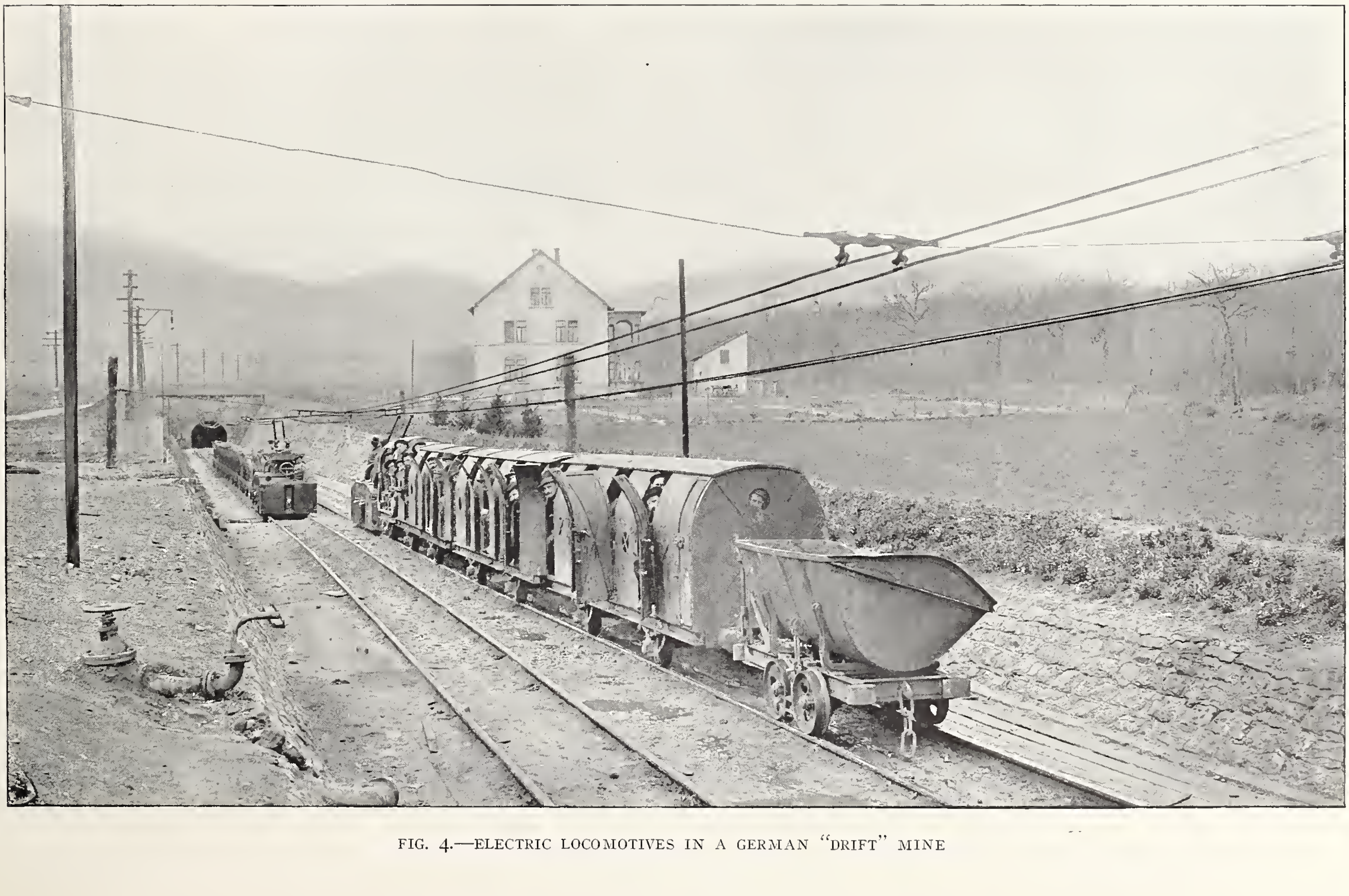


FIG. 4.—ELECTRIC LOCOMOTIVES IN A GERMAN "DRIFT" MINE

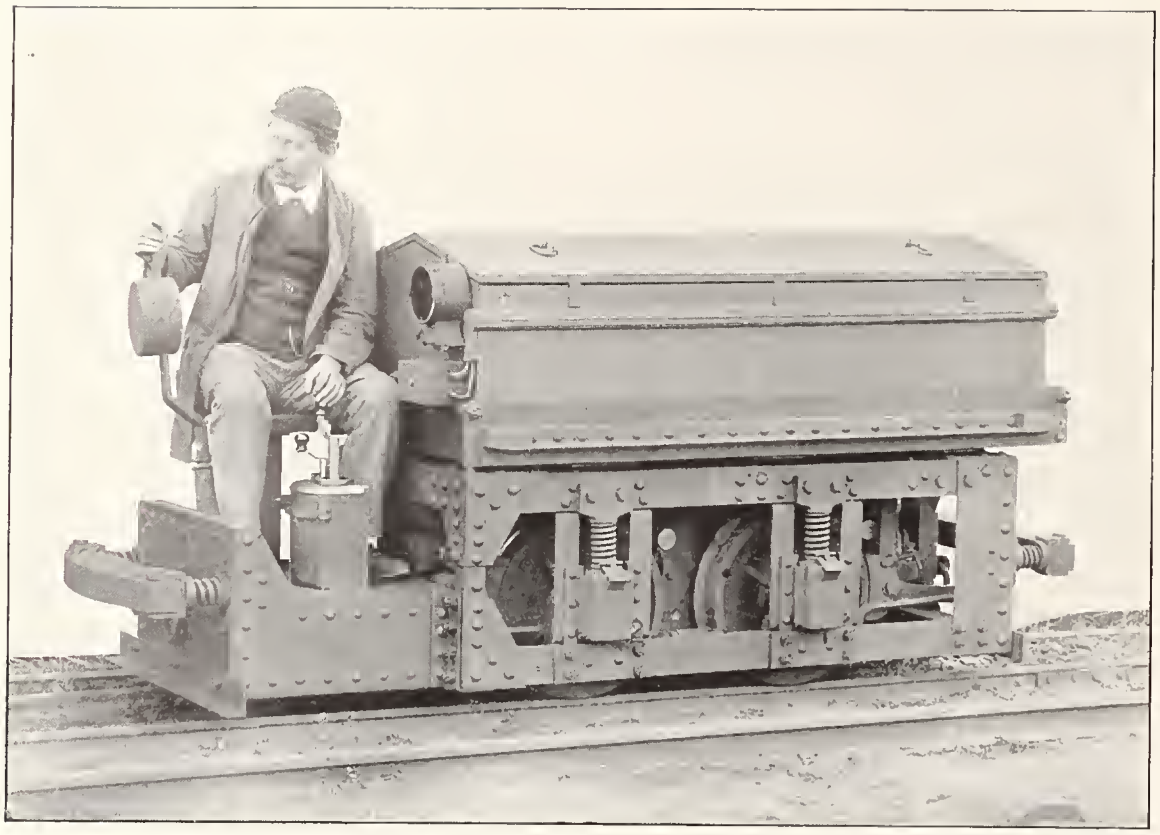


FIG. 5.—A STORAGE BATTERY LOCOMOTIVE BUILT BY MESSRS. SIEMENS & HALSKE, BERLIN

a shunting engine at a large iron works in Sweden. The locomotive is designed to draw a load of 70 tons, exclusive of its own weight, at a maximum speed of $4\frac{1}{2}$ miles per hour. Current is suplied at a pressure of 300 to 330 volts. The gauge is standard and the wheels are of steel, 27 inches in diameter, the wheel base being 4 feet 6 inches. The side frames of the locomotive are of steel, and are somewhat deep for the size of the car, owing to the height of the buffers above the rail. The general design of the cab is similar to those built by Messrs. Mather & Platt, for the City and South London Railway. The motor is of the double-armature type made under the patents of Drs. J. & E. Hopkinson. Owing to the slow speeds at which the axles have to run the armatures are connected to them by means of spur gearing in the ratio of 10 to 1. There are two main switches, one of which is for stopping and starting by inserting or cutting out resistances from the main circuit, or for cutting off the current altogether, and the other is for reversing and for entirely breaking the connection between the locomotive and the main conductor.

The locomotive is arranged with overhead collecting gear, which has had to be carried to a height of about 16 feet from the rail, owing to the necessity of clearing certain obstacles with the bare overhead conductor. As a protection against the weather the whole of the working parts is boxed in, as well as all the connections to the collectors, etc., this being necessary on account of the heavy falls of snow experienced in winter.

Fig. 3 illustrates a locomotive recently built by Mather & Platt for mining service. This locomotive is of standard gauge, and is fitted with a motor on each axle, and a series-parallel controller. It is designed to haul 13 tons on a grade of 1 in 33 at a speed of ten miles an hour, when supplied

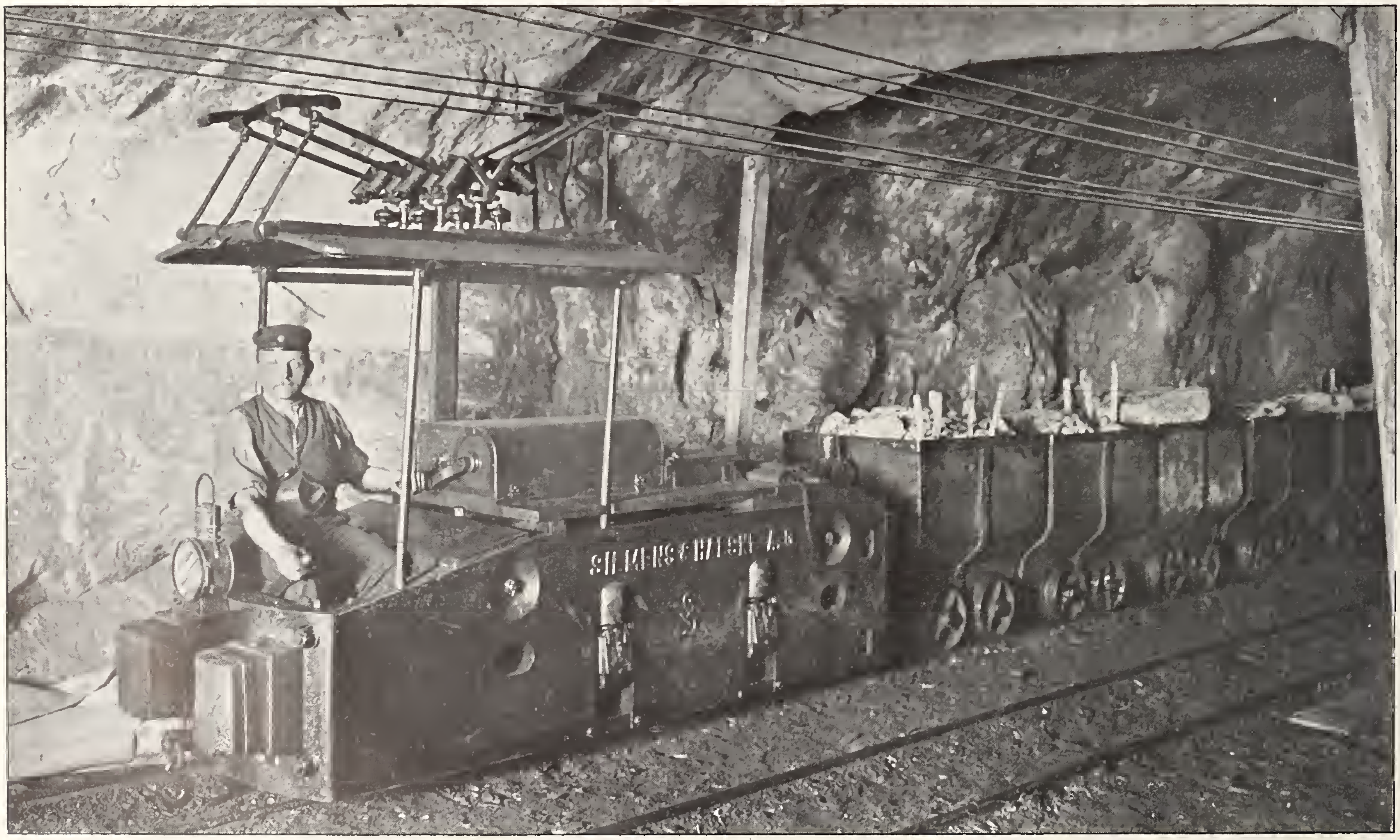


FIG. 6.—A THREE-PHASE MINE LOCOMOTIVE BUILT BY MESSRS. SIEMENS & HALSKE

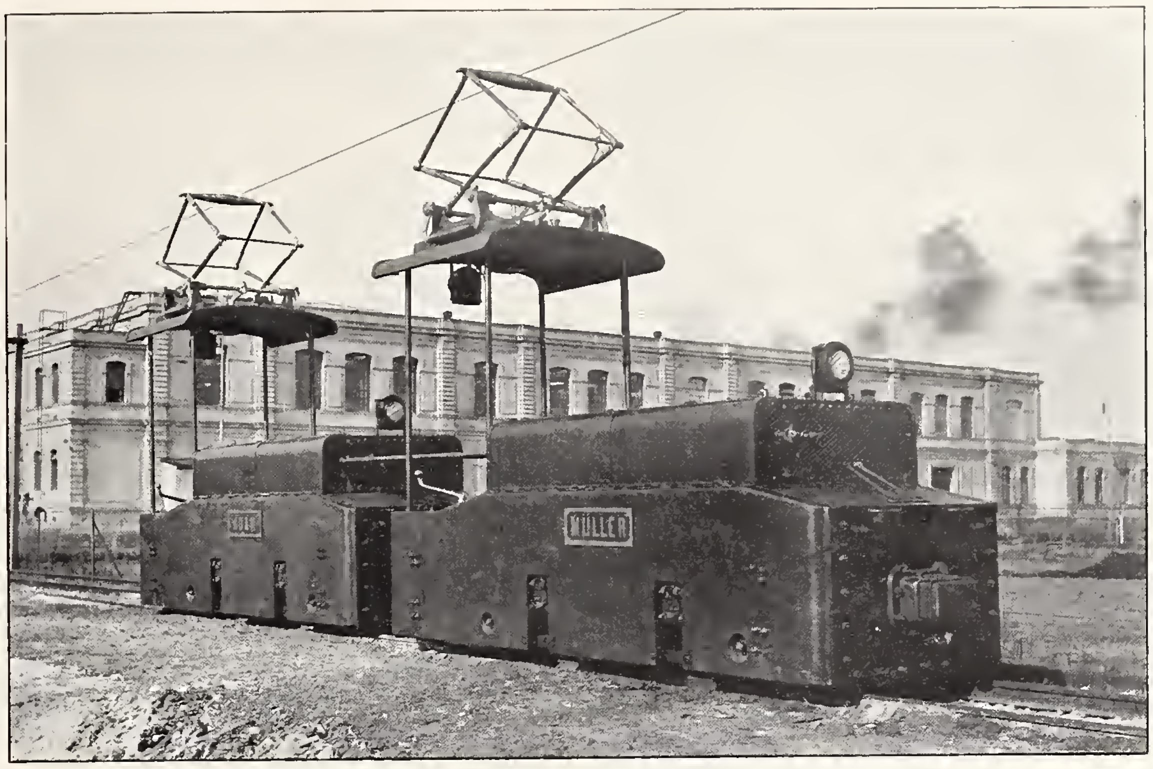


FIG. 7.—A SIEMENS & HALSKE DOUBLE LOCOMOTIVE

with current from the overhead conductor at a pressure of 500 volts, the return being by the rails. Current is conveyed from the overhead wire to the motors through two automatic reversible bar-collectors, instead of trolley poles. It is fitted with a powerful hand screw brake, spring buffers, spring drawhook, and link at each end, sanding gear, head and tail lights in duplicate and foot gong. In addition to the series-parallel controller, there are also fitted in the cab an automatic cut-out lightning arrester, kicking coil and the controller resistances. The motors are entirely enclosed and carried partly on the axle and partly by springs from the under frame; they drive the axle by means of single reduction machine-cut gear, running continuously in oil. The weight of the locomotive in working order is about $5\frac{3}{4}$ tons.

The Electrical Construction Company and Messrs. Ernest, Scott & Mountain, Ltd., of Newcastle-on-Tyne, have also built several electric locomotives, and the British branches of some of the American firms also supply locomotives of the American types. Messrs. Kerr, Stuart & Co., Ltd., also catalogue a very small style of electric locomotive, more particularly designed for use where headway is limited, and adapted especialy for "gathering" work in mines. A few of these have been built, though as no photographs are available they cannot be illustrated.

The last-named engines are built of varying sizes, the smallest design having a 1-H. P. motor, and are capable of dealing with a load of 2 tons on the level at 5 miles an hour, while a larger type, with a 30-H. P. motor, is intended to haul 60 tons on the level or 15 tons on a grade of 1 to 20. We will deal now with examples of electric locomotives as built by Messrs. Siemens & Halske. Fig. 5 illustrates an accumulator locomotive supplied to the Kohlenberwerk Vereinigter Bonifacius zu Kray—Gelsenkirchen. Fig. 4 shows an interesting scene outside a German "drift" mine. On the one track is a mine passenger train ready to take miners to work, and on the other track is a loaded coal train just out of the mine. In this case there are double overhead conductors.

Fig. 6 is an interior flashlight photo showing a three-phase, alternating-current locomotive at work. In Fig. 7 a double electric locomotive is illustrated as usual in several German mines. In this case the two locomotives are normaly worked as one, the driver on one unit governing the whole; though, if need be, either section can be operated independently and used as a single locomotive. These double locomotives are employed when adequate power cannot be obtained without unduly increasing the size and weight of an ordinary locomotive or exceed-

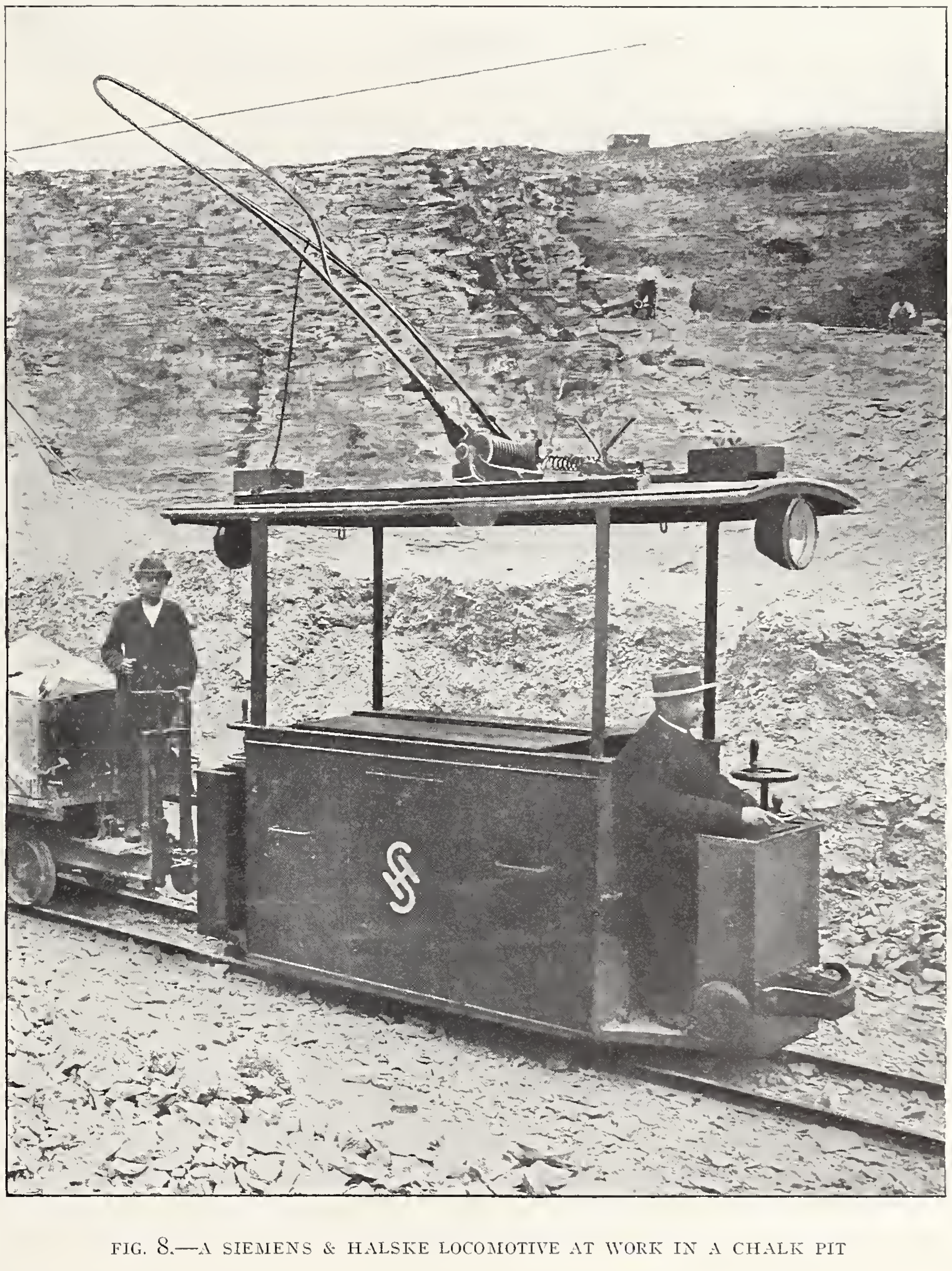


FIG. 8.—A SIEMENS & HALSKE LOCOMOTIVE AT WORK IN A CHALK PIT

FIG. 9.—AN ITALIAN QUARRY ELECTRIC LOCOMOTIVE BUILT BY MESSRS. SIEMENS & HALSKE

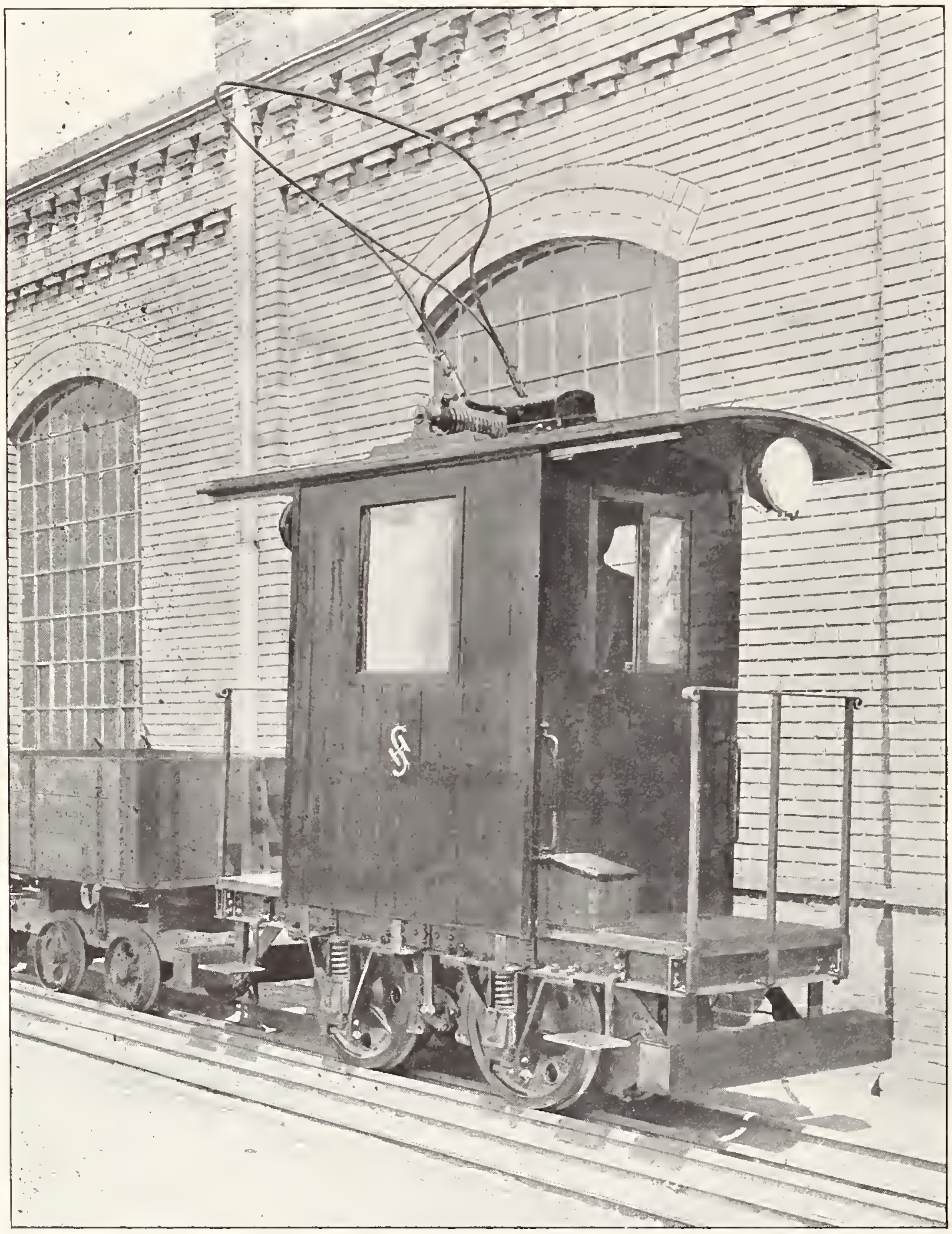


FIG. 10.—A SIEMENS & HALSKE FACTORY LOCOMOTIVE

ing the allowable load for each axle.

Fig. 8 illustrates a neat design of locomotive, with overhead conductors at work in a chalk pit. In this case the height and width of the locomotive are not restricted, so that, in outward appearance, the locomotive differs from the mine locomotives previously described.

Fig. 9 shows another design as used at an Italian quarry. In this case double collectors are fitted so as to ensure constant contact with the overhead conductor, a practice usual for tramway and railway work, though rather rare for industrial service.

Fig. 10 illustrates another design as used about factories and the like; and Fig. 11 shows an interesting scene upon the Berlin Overhead Railway, the locomotive being used for hauling construction trains. In this instance, double conductor rails, which can be seen between the running rails, are provided for the supply and the return of the current. The rough-and-ready arrangement of the narrow-gauge rails is worthy of notice as showing "how things are done."

Fig. 12 illustrates an interesting design of electric locomotive adapted for working over stiff gradients. Between the rails is fitted a chain, along which the locomotive hauls itself by means of a motor-driven drum, around which the chain is passed. The rail wheels are also driven by the motor. This locomotive, with three others, was supplied to the Roeros copper mines in Norway in 1895. The grade is 30 per cent.

Fig. 14 illustrates a locomotive which also serves the purpose of a platform wagon—a form of locomotive for use about works in conveying goods from one shop to another and for like work.

In addition to the illustrated examples of locomotives, built by Messrs. Siemens & Halske, there are many variations, and they range from small engines for running "fair" and "show" railways—in such machines the motor casing forms the seat for the driver—to large eight-wheeled locomotives for heavy work. Some have only one motor, others have two. Various systems of control are adopted, and there is great diversity in the construction and arrangement of current-collectors, through the plain trolley pole as used so extensively in Great Britain and America is rather uncommon. Most of the systems of electrical distribution which are practically successful are in use from the ordinary low-voltage, continuous-current to the high-tension, three-phase, alternating-current systems.

The A. E. G.—as the Allgemeine Elektricitaets Gesellschaft, of Berlin, is generally termed—have also done good work in connection with electric locomotives for the industrial service, and a few examples of their work will now be given.

Fig. 13 illustrates a storage battery

locomotive, as supplied to a French steel works, hauling a train of foundry ladles. In this case, the motor drives one axle and coupling rods are employed.

The locomotive shown in Fig. 15 is for mining service, and is a good example of stock and ordinary design, though the arrangement of current-collectors is rather unusual. Fig. 16 shows a large double-ended locomotive, built by the Union Elektricitaets Gesellschaft, now amalgamated with the A. E. G.

There are several other Continental firms who do a good business in electric locomotives for mining and like work, but enough has been said to indicate the principal characteristics of the designs in use. Suffice it, then, to mention that Messrs Ganz & Co., of Buda Pesth, have equipped several mines with electric locomotives working on the high-voltage, alternating system with which their name is now so prominently associated.

In American practice there is more uniformity among the various locomotive types as now built than in the case of the German designs.

Figs. 17 and 18 illustrate two examples of overhead trolley locomotives built jointly by the Baldwin Locomotive Works and the Westinghouse Electric and Manufacturing Company—one for the Berwind-White Coal Mining Company and the other for the St. Louis and Big Muddy Coal Company, both of which are of substantially equal dimensions and power, though they differ considerably in details of design. In the one case the gauge is only 3 feet, and in the other case it is 3 feet 8 inches, but both are designed to give a working capacity equal to 100 H. P., at a speed of 8 miles an hour on the level. One 50-H. P. single-reduction motor, suitable for a pressure of 500 volts, is geared to each axle. The draw-bar pull for both engines is estimated at 4300 pounds on the level. Rheostatic controllers are fitted. The differences in details will be apparent on inspection of the photographs.

Of a different class, built by the same firm, and intended for surface work, is the locomotive illustrated in Fig. 19, belonging to the Golden Sceptre Gold Mining Company. In this case, larger dimensions are available, and so the engine is of a more ordinary type, and a proper casing is provided. The engine is guaranteed to exert 100 H. P. continuously for three hours at a speed of 6 miles per hour, and to haul a train of mine cars, weighing, in all, 35 tons, up a maximum grade of 1 to 20.

Two 50-H. P. double-reduction, consequent-pole motors are employed, one geared to each axle, the wheels being coupled.

Fig. 20 shows a double-ended mine locomotive built by the General Electric Company, of Schenectady, N. Y., and Fig. 21 represents a storage battery locomotive by the same builders, for yard switching and general service about factories. Fig. 23 shows an interesting type of electric locomotives made by the Jeffrey Manufacturing Company, of Columbus, Ohio.

The locomotives described may be said to represent American practice fairly thoroughly, but this article would not be complete without reference to some special designs for which the Goodman Manufacturing Company, of Chicago, is responsible. This company exploits the Morgan third-rail system, which has been introduced with good results in mines having steep grades. This system simplifies the arrangements for supplying current to the locomotives.

Figs. 24 and 25 illustrate some of the construction details.

There are two standard types of locomotives used at the present time in operating this system:—First, that with a single motor of 75 H. P.; weight, complete, 6000 pounds; maximum height from top of rail, $3\frac{1}{2}$ feet; length, 7 feet; minimum gauge, 18 inches; second, the two-motor type of 150 H. P.; weight, complete, 10,000 pounds; maximum height from top of rail, 4 feet; length, 10 feet; minimum gauge, 18 inches. The motors for either of these two locomotives are wound for 250 or 500 volts, as required. The locomotive itself consists of a substantial steel frame, mounted on suitable track wheels. On this steel frame are mounted two steel sprockets or traction wheels—see Fig. 25—which are driven by one or more electric motors (according to the class) contained in the body of the locomotive, by means of suitable gearing. The sprocket wheels which engage the third rail serve the double purpose of driving the locomotive along the track and taking up the current from the rail to feed the electric motor; hence the name "combined third and traction rail." The sprocket wheels are geared to always run in unison, all difficulty in crossing switches or other openings in the track thus being avoided.

The track rails are used as the re-

FIG. 11.—A SIEMENS & HALSKE ELECTRIC LOCOMOTIVE ON CONSTRUCTION WORK IN CONNECTION WITH THE BUILDING OF THE BERLIN OVERHEAD RAILWAY. NOTE THE DOUBLE CONDUCTOR RAILS BETWEEN THE RUNNING RAILS

FIG. 12.—A SIEMENS & HALSKE LOCOMOTIVE WITH CHAIN HAULAGE AUXILIARY FOR VERY HEAVY GRADES

turn conductor. The third rail consists of heavy iron bars, perforated at regular intervals throughout their entire length, and made into a continuous rail by means of fish-plates, much the same as regular track rails. This continuous rail is enclosed and depressed in a specially prepared wood casing, which serves the double purpose of insulating the rail and protecting men and animals from the current. It is laid 5 inches off the center of the regular track, thus giving room for mules to work over the same rails and avoiding interruption to the working of the mine while the plant is being installed.

The sizes of third rail manufactured at the present time are designated as standard, heavy, and special. The standard third rail is usually used with the one-motor locomotive, the heavy with the two-motor locomotive, and the special with either the standard or heavy for curves and switches. All sizes are furnished in straight 16-foot lengths.

A special "jim-crow" is furnished, which easily bends any of the above mentioned sizes of third rail to suit any curve met with in a mine. The various sizes of third rail are perfectly interchangeable—that is, any of the third-rail locomotives will work well over either standard, heavy or special third rail. Special arrangements have to be made at switches and crossings, but these cannot be considered here.

Fig. 26 illustrates a large double-motor third-rail locomotive.

The Goodman Company have also designed a locomotive for work with a headway of 32 inches only—probably the least ever attempted to work with mechanical haulage anywhere. In mines where the men can push the cars out of the rooms, mules can be dispensed with entirely by using these small locomotives, a great saving thus being effected. This company also build locomotives of more ordinary design, taking current from a trolley wire or from a conductor rail, but space will not permit of any of these being illustrated.

As a rule the continuous current, low-voltage system is employed in the United States, though there are a few examples of the use of three-phase alternating currents.

It is very usual, too, to adapt electric coal-cutting machines of various kinds to self-propulsion by gearing the driving motor, when required, with one of the wheel axles of the carriage. Propelling motors are also fitted to "larrys," for feeding coke ovens, and sometimes these motor-larrys will haul several trailers when required.

An electric automobile ordered by the Board of Fire Commissioners for the fire chief of San Francisco was delivered recently. It is of 16 horse power and has a guaranteed speed of 20 miles an hour. It has double brakes and is fitted with a search-light that can be detached and used to explore the interior of a burning building.

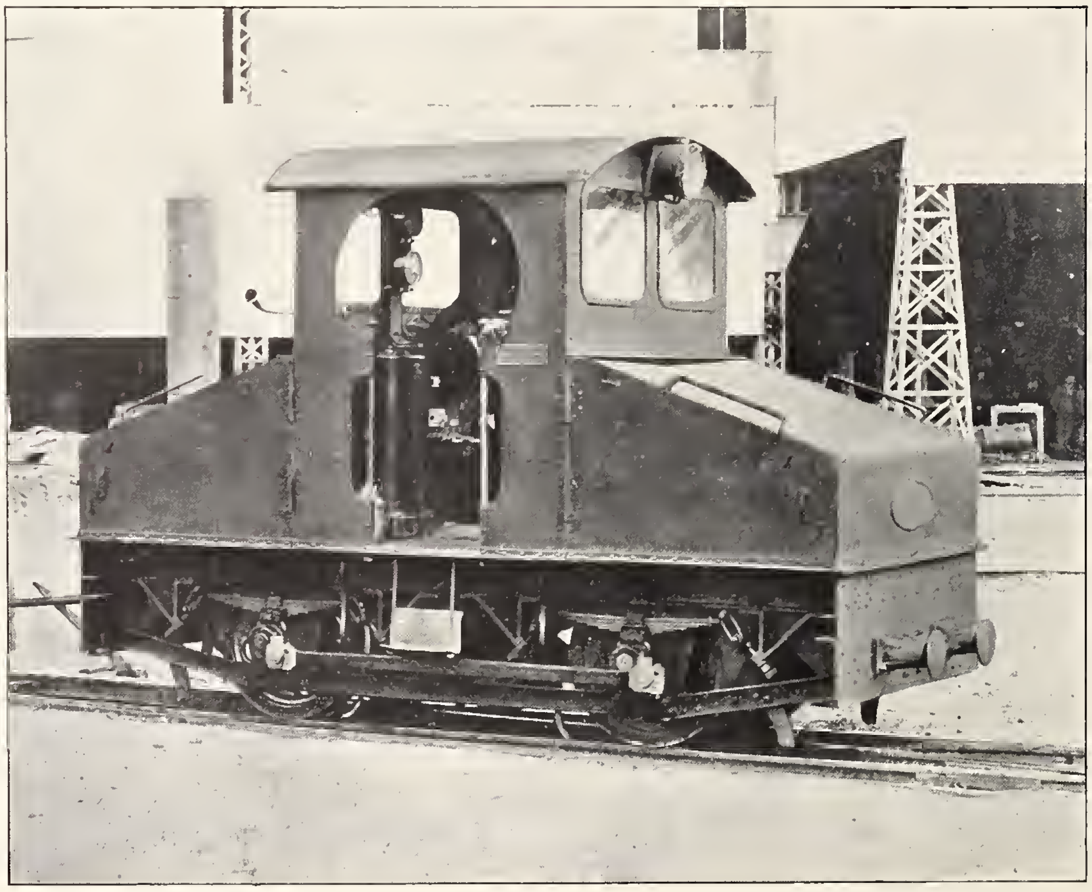


FIG. 13.—A STORAGE BATTERY LOCOMOTIVE MADE BY THE ALLGEMEINE ELEKTRICITAETS GESELLSCHAFT OF BERLIN

Hydro-Electric Power in Mexico

THE utilization of the energy produced by the waters of the numerous rivers of the Republic of Mexico for the purpose of generating electric power, has recently attracted a great deal of attention, with the result that several small hydro-electric power plants have been put into operation.

This power, according to F. C. Roberts, in "The Engineering and Mining Journal," is being utilized principally for operating the machinery in connection with textile and other factories, as well as for lighting purposes. The success which has attended these initial efforts has induced a more thorough exploitation of these sources of power, the effect of which has been the recognition of large possibilities in the department of engineering. At the present time there is one plant being actually installed which, it is estimated, will develop 18,000 to 20,000 H. P., and another is in contemplation which will furnish 43,000 H. P. Both of these are within 150 miles of the city of Mexico. Activity in the same direction is further emphasized by numerous applications recently filed for water rights in several States of the Republic.

The benefits which will accrue to the mining industry through the introduction of cheap power for the operation of reduction works, hoisting works and pumps, etc., will no doubt reanimate the mining districts which come within the radius of the power distribution, while the additional possibility of introducing electric furnaces may render commercially important a number of mines which, under existing conditions, are considered too low in grade to permit of further exploitation. Equally beneficial effects will be felt in other industries which exist within the radius of economical distribution.

A series of falls occurring in the Necaxa River in the State of Puebla and distant 115 miles from Mexico city, are at present being equipped with hydro-electric plant, and it is expected that this power will become available for use in about fifteen months. The centers of utilization will include the mining district of El Oro, besides one or more districts of lesser importance, within a few leagues of the generating station and the cities of Mexico and Pachuca. It is estimated that the several mining companies in El Oro district will avail themselves of about 5000 H. P. The transformation from steam to hydro-electric power will result in a substantial reduction in the cost per ton of ore handled.

Mexico City is at present by far the most important consumer of power in the Republic. The requirements here are about 20,000 H. P., and the increase in consumption during the past three years has been at the rate of 2000 H. P. per annum, so that with the introduction of a cheaper power a substantial increase upon these figures may be reasonably anticipated.

It is stated that the minimum constant flow of the Necaxa River is 3500 liters per second, and that the total available head is 400 meters; that is to say, a theoretical constant minimum power of 3500 multiplied by 400 and divided by 75, or 18,666 H. P. The contours of the country admit of utilizing other falls, some distance above the present installation, but for the time this power only is under consideration. The total length of this transmission will be 115 miles to Mexico city and 160 miles to El Oro.

If, therefore, the following losses are admitted, namely, 0.75 turbines and friction, 0.95 generators, 0.98 transformers elevating tension, 0.88 lines of transmission, 0.98 transformers lowering tension, the general return will be:—0.75 multiplied by 0.98, by 0.95, by 0.88, by 0.98, the product being 0.60. Therefore, upon this showing, there would be a minimum constant power produced of 18,666 multiplied by 0.60, or 11,200 H. P. distributable in the centers of utilization.

The consumption of electrical energy is far from being constant, says Mr. Roberts, and the major portion of power is consumed during the day. It has been noted in many electrical establishments that this maximum is equal to 1.75 multiplied by the average consumption. By a conservation of the waters of the river during the hours of small demand, a maximum power of 11,200 multiplied by 1.75, or 19,600 H. P. will, therefore, become available for distribution during the hours of superior demand.

The undertaking forms a striking example of what capital, combined with engineering skill, can accomplish, and the enormous benefits which will be felt in consequence by the mining, manufacturing and other

FIG. 14.—A PLATFORM FACTORY LOCOMOTIVE BUILT BY MESSRS. SIEMENS & HALSKE, BERLIN. SEE PAGE 96

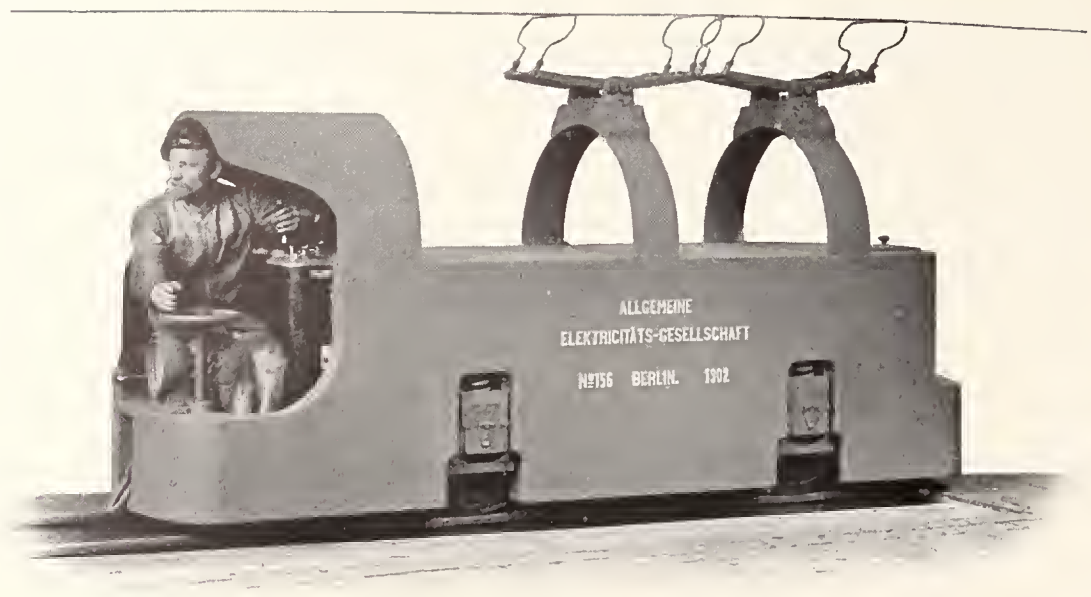


FIG. 15.—A MINE LOCOMOTIVE BUILT BY THE ALLGEMEINE ELEKTRICITAETS-GESELLSCHAFT, BERLIN. SEE PAGE 96

industries will tend to make Mexico more attractive as a field for investment.

The demand for electricians in the Artillery Corps of the United States Army is far in excess of the supply. The positions open require a certain amount of technical knowledge which seems to be the drawback. The salary of $75 a month is the highest of any of the enlisted force, yet it appears that the restrictions of the life are too great to attract capable men.

Boiler Power in Electric Light and Power Stations

AMONG the uncertainties of engineering, says "The Engineer," of London, boiler power takes a high position. Outside a somewhat limited circle no one seems to know exactly how much power any given boiler will supply. It may be taken as a rule to which there is really no exception that the power of land boilers is invariably overrated. If ample boiler power is supplied in the first instance, as time progresses, more and more work has to be done, and the boilers are taxed more and more heavily.

The reason is very easily found. Boilers are expensive; they take up much room; they are often handled with great difficulty, and not a little risk. There is always the risk of explosion to be thought of; corrosion, pitting, and various other diseases. It is not in any way wonderful that boilers are unpopular, and that steam users feel that the fewer of them they possess the better. This is an altogether mistaken view to take. Most of the troubles we have indicated are brought about by want of boiler power. Had there been more boilers there would really have been less risk, less worry, less expense.

Thus, it is safe to say that much more than half the money paid in fines for causing a smoke nuisance would have been saved if only more boiler power had been provided. The makers of automatic furnace feeding apparatus are specially interested in this fact. When there is plenty of boiler power machine stokers will give complete satisfaction; whereas with boilers too small for their work, the machine stoker finds its way to the scrap heap, and men take its place.

Among marine engine builders mistakes as to boiler power are seldom made. Marine engine and boiler

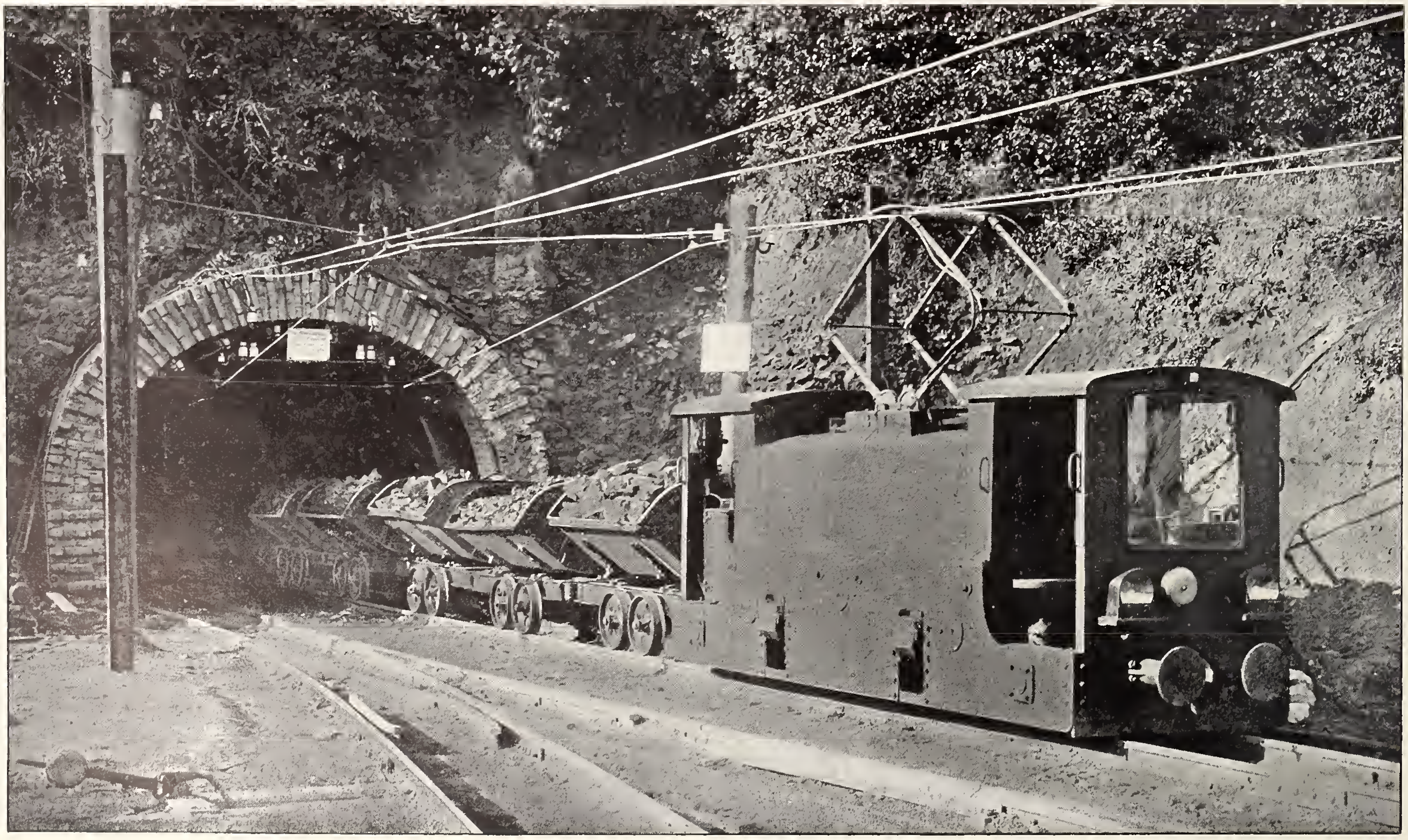


FIG. 16.—A DOUBLE-END LOCOMOTIVE MADE BY THE UNION ELEKTRICITAETS-GESELLSCHAFT, BERLIN. SEE PAGE 97

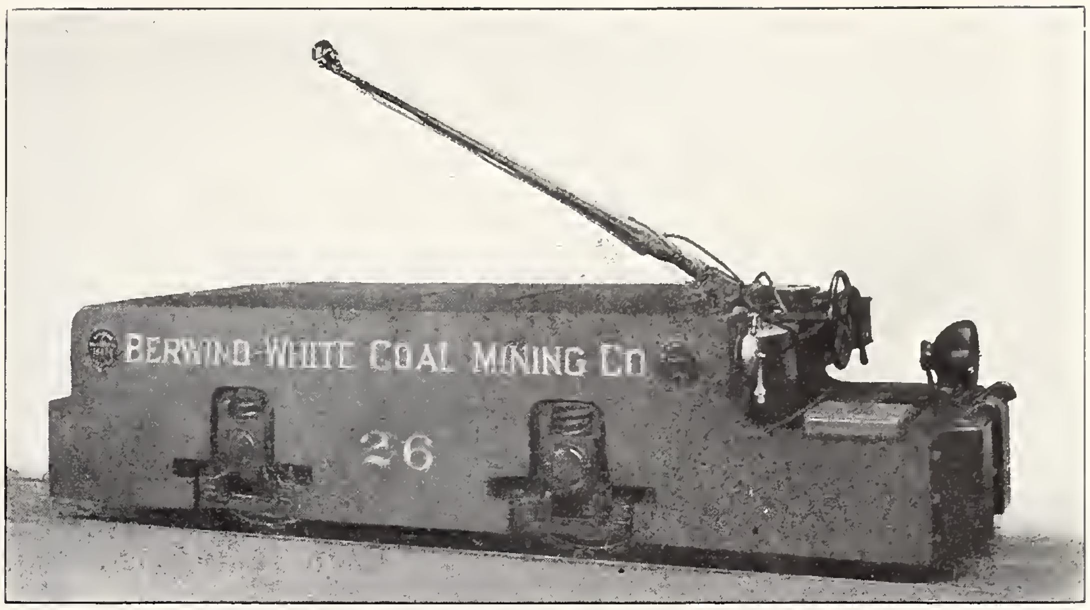
making for the mercantile service has become a matter of routine; and, besides, if the power is not quite what it ought to be, the only result is that the ship goes a little slower, which is not a very serious defect.

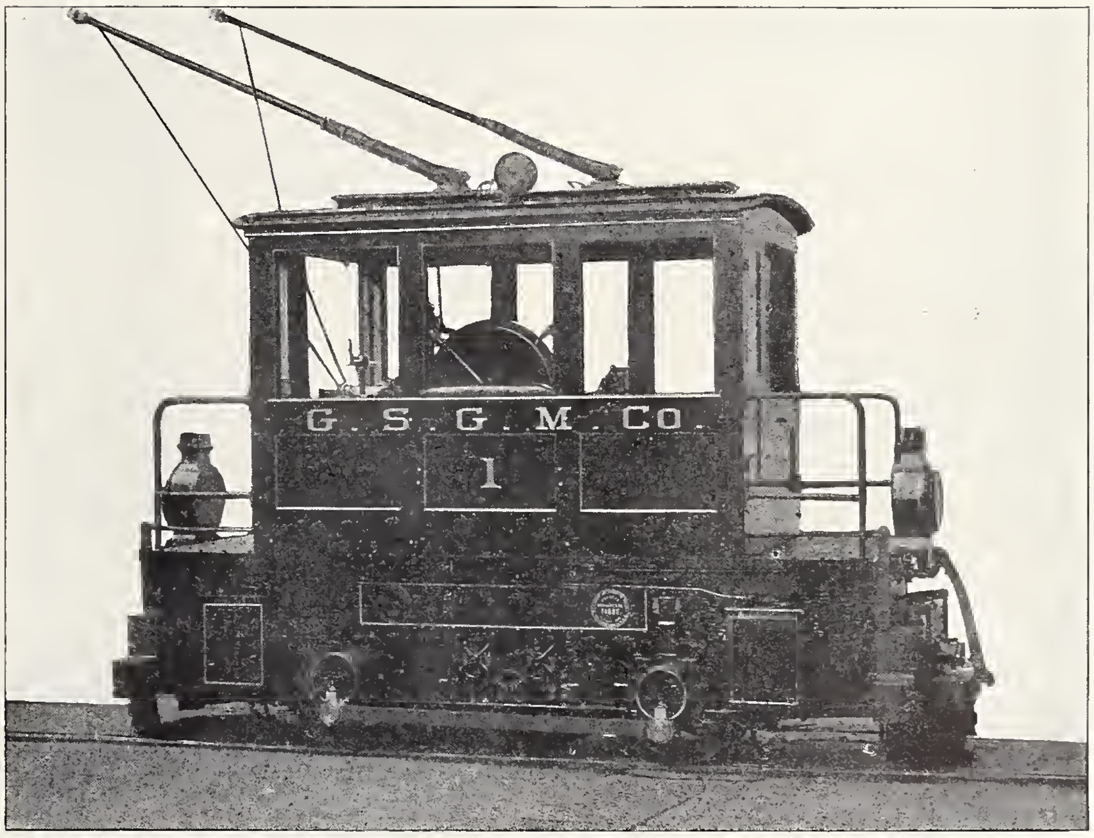
The lack of boiler power tells most heavily on electric light and power stations. It results partly from the reasons we have already given, and partly from the fact that boiler engineering is not so well understood as it ought to be. We are repeatedly asked what the power of a given boiler, or group of boilers, may be; and that by engineers who ought to understand the whole subject. No doubt a good deal of confusion has been caused by statements concerning the quantity of water that a square foot of heating surface can evaporate per hour; by disquisitions on the number of heat units which a given area of plate can pass through its thickness, and various other lucubrations of the same kind, which are usually more or less misleading.

There are, fortunately, one or two very simple rules for determining the power of a boiler, which have no claims to scientific precision, which are purely empirical, and yet, being founded on practice, may be taken as altogether trustworthy. It may be assumed with substantial accuracy that a boiler will produce 8 pounds of steam for every pound of reasonably good coal burned on the grates in the furnaces. We presuppose good modern practice, the feed-water being heated by economizers. If, now, we know how much coal can be burned in any given time, in or under a boiler, we can tell what the power of that boiler is.

For example, let us take a Lancashire boiler, 8 feet in diameter and 30 feet long. Such a boiler will have about 36 square feet of grate surface, and with a good draught will burn 15 pounds of coal per square foot per hour, or in all 540 pounds. Eight times this is 4320 pounds. If, now, the engine, being fairly good, requires 20 pounds of steam per indicated horse-power per hour, then the boiler will develop 216 indicated horse-power. If the engine is very much better, and requires but 15 pounds per indicated horse-power per hour, then the boiler may be taken as equal to 288 indicated horse-power, and so on.

It will be seen that the engineer of an electric light or power station has two uncertain, or, rather, two initially undetermined factors to deal with—namely, the rate at which his furnaces will burn coal, and the quantity of steam which his engines will require. As regards the latter factor, it will be found that, generally speaking, engine builders of reputation will guarantee the consumption of steam. Thus, if a consumption of, say, 14 pounds per indicated horse-power is promised, it may be accepted that the engine will not for a considerable period require more, always provided that piston rings and valve faces are kept in good





FIGS. 17, 18 AND 19.—DIFFERENT FORMS OF BALDWIN-WESTINGHOUSE ELECTRIC LOCOMOTIVES. SEE PAGE 97

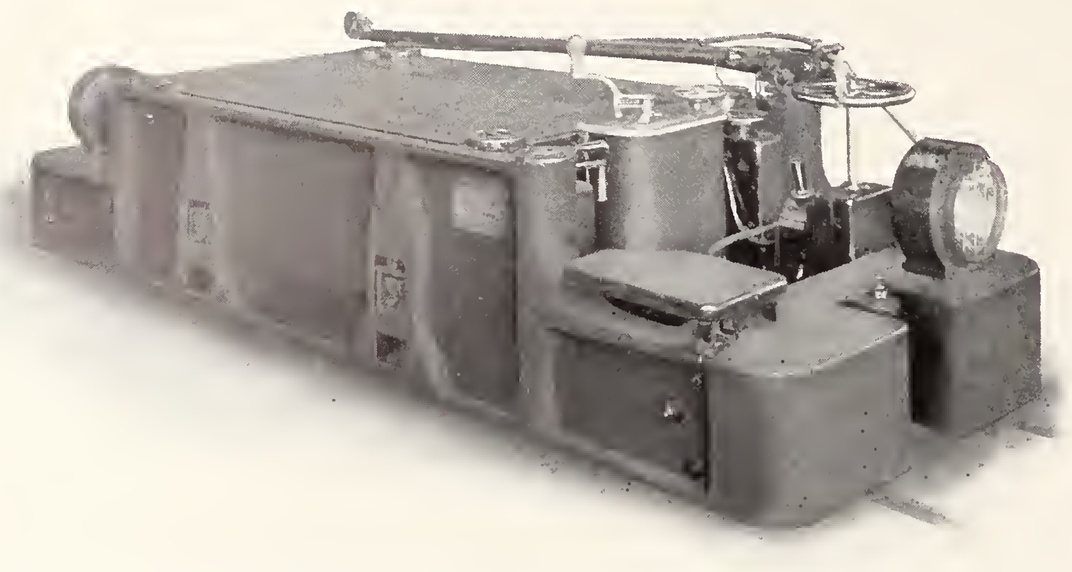


FIG. 20.—A DOUBLE-END MINE LOCOMOTIVE BUILT BY THE GENERAL ELECTRIC COMPANY, SCHENECTADY, NEW YORK. SEE PAGE 97

order, and that the engine is not overloaded.

In no case of the kind will the engineer be able to excuse himself should he be short of power, on the plea that he did not know how much steam would be wanted. About the quantity of coal that can be burned there is much more uncertainty. Tall chimneys are very costly, often very unsightly. Not infrequently an amount of draught is reckoned upon that cannot be had. Thus, we have met with a case in which, when the products of combustion were sent through a Green's economizer, steam could not be kept up. Chimney engineering is by no means the exact science that some text-books would have us believe, because there are multitudinous conditions affecting the draught.

In practice it will be found that good coal well fired can be burned at any rate from 12 pounds to about 18 pounds per square foot of grate per hour, without the aid of fans or forced draught. Of course, given sufficient forced draught, and there is hardly a limit to the rate of combustion other than the difficulty of preventing the fuel from being lifted off the grate and carried up the chimney, as used to occur in the earlier torpedo boats, when the air pressure in the stokehold reached 7 inches or even 8 inches of water. We have spoken only of a Lancashire boiler, the grate area of which is restricted. A point much in favor of the water-tube boiler is that the grate can be made very much larger in proportion, and so more power can be had in a given space. Yet it must not be forgotten that, the chimney remaining the same, the rate of combustion per square foot per hour will be higher with the small grate than with the large one.

It must be understood that in what we have written we have done no more than supply a simple method of arriving at the power of any steam generator. The coefficient of evaporation which we have given—8 pounds per pound of coal—is based on extended experience. Many boilers do better, but it would not be safe to reckon on this. On the other hand, boilers doing worse ought not to be retained in any power house pretending to be up to date. Of course, it may be found, on the whole, economical to use cheap slack instead of better coal; but the engineer can allow for this. Under all circumstances, power enough should be provided to permit boilers to be laid off for cleaning and repairs; and, finally, we may say that the engineer can never regret having too much boiler power, while the lack of it will make life a burden too heavy to be borne.

Electrical Ore Finding

A DEMONSTRATION of the Daft-Williams ore-finding apparatus was given recently, according to London "Electrical Review," before an audience of electrical engineers at the Westminster Palace Hotel. The proceedings commenced with the reading of a paper on the system by Mr. Alfred Williams, in which he outlined the history of the subject, and instanced a number of successful prospects carried out with the apparatus in various parts of the world.

The system is such that by means of an apparatus involving the use of high pressures, obtained by means of an induction coil and spark gap, electrical impulses are transmitted into the earth, and the distribution of the resulting waves is explored with the aid of a telephone receiver, the terminals of which are connected with

FIG. 21.—A STORAGE BATTERY SHUNTING LOCOMOTIVE BUILT BY THE GENERAL ELECTRIC COMPANY, SCHENECTADY, NEW YORK. SEE PAGE 97

two electrodes which are stuck into the ground at a suitable distance apart. The varying intensity of the sounds heard in the receiver, depending upon the conductivities of the underlying strata, and strongly affected by the presence of mineral lodes or veins, whose conductivity differs materially from that of the surrounding soil, affords a clue to the direction, depth, and, it is said, even the character, of such lodes.

Dr. S. P. Thompson, whose presence on the platform, says the "Electrical Review," naturally gave the proceedings an importance which might otherwise have been lacking, discussed the system from a scientific standpoint, and described his own experiences with the apparatus. Dr. Thompson expressed his approval of Mr. Williams' modest claims for the capabilities of the apparatus, which was not supposed to work miracles. After briefly describing the principles of the system, he reminded the audience that electricity does not travel solely by the path of least resistance, but by every possible path. The presence of ore lodes distorted the electrical field, even when they were of a non-conducting character, such as quartz reefs. It was quite certain, said Dr. Thompson, that when there were well-defined lines of ore underground, they could be localized by means of that apparatus.

He had been very skeptical at first as to the practicability of the system, but had personally explored a rocky hillside in Wales, where lodes of galena were being worked, and had himself traced the course of a lode; he was now quite convinced that the method was applicable to galena and other conducting ores, but could not say whether it would prove useful in gold mining. He was anxious not to overrate its capabilities, but he believed that it would do good service in tracing the direction of known lodes, and would effect great savings generally in exploring for ore.

The results obtained with the apparatus on property in Cumberland were also described. In this instance not only had the inventors mapped out veins of ore which were known to exist in a certain area, but Mr. Williams, in tracking a lode of lead ore from the outcrop, discovered two unknown veins, which he identified as copper ore, and it was subsequently found that these veins were recorded in old maps, but had been totally forgotten

FIG. 22.—A PLANTATION LOCOMOTIVE BY ARTHUR KOPPEL, OF LONDON, BERLIN AND NEW YORK

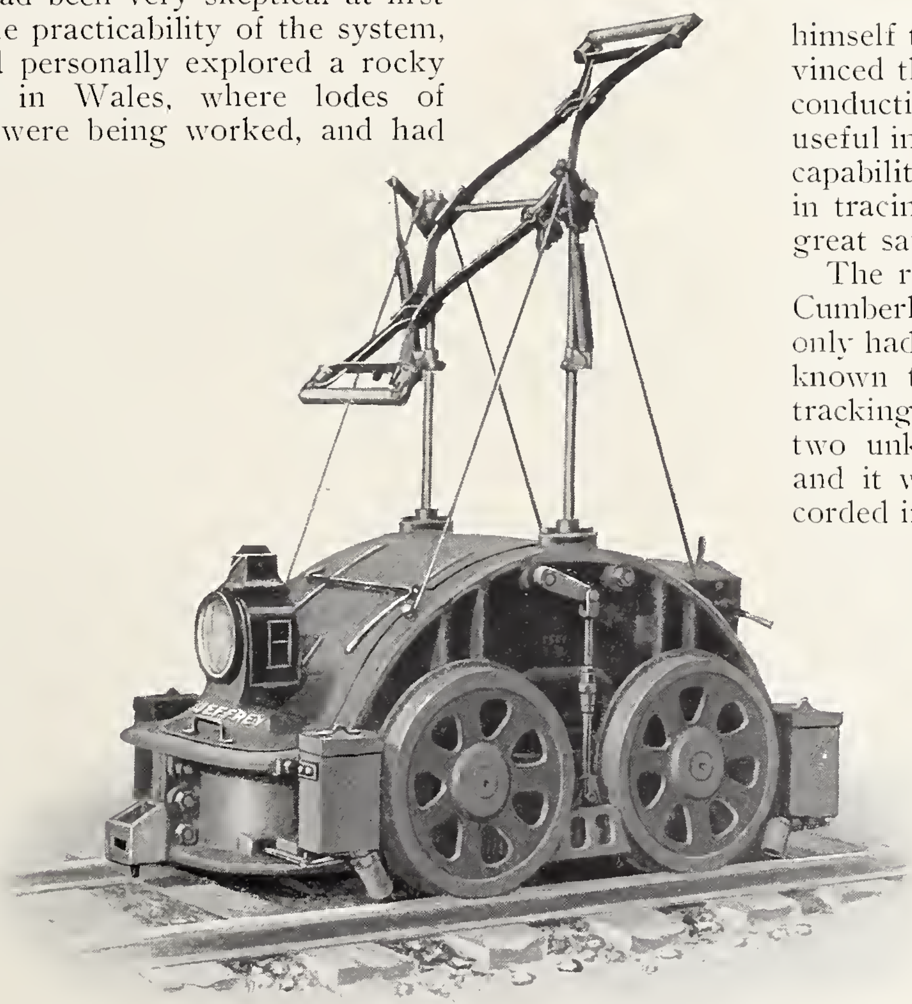


FIG. 23.—A GONDOLA TYPE ELECTRIC LOCOMOTIVE MADE BY THE JEFFREY MFG. CO., COLUMBUS, OHIO. SEE PAGE 97

The filament in glow lamps gradually diminishes in diameter in consequence of the slow volatilization of the carbon. According to the "Elektrotechnische Rundschau," a German firm introduces into the glass globe certain chemical compounds with a high boiling point; these, under the influence of the temperature in the lamp bulb, slowly giving off vapors containing carbon, which is deposited on the filament, thus making up to a large extent for the loss referred to above, and keeping the resistance and also the brightness of the lamp more uniform throughout its useful life.

The Electrical Fire Hazard

By J. C. FORSYTH, Chief Inspector for the New York Board of Fire Underwriters

IN this age of wireless telegraphy and wireless telephony we may soon reach the stage of a practical wireless electric lighting and power service; but as it is a "condition and not a theory" which confronts us, we are obliged to deal with matters electrical as they now exist, and not as we may hope to have them in the future.

From the standpoint of the electrician or electrical engineer the marvelously rapid growth of the electrical industry during the last two decades may be interesting, but from the point of view of the individual or corporation who has to carry the fire "risk" and pay the loss, the roseate tints lose their entrancing power, and in a correspondingly increased ratio assume a "fiery red" which it is difficult to contemplate without varied emotions of dread and apprehension.

We are told, and it is undoubtedly true, that electricity is the safest form of artificial illumination and power that is available if the prescribed standards are followed and if proper maintenance and supervision are given. How those "If's" do loom up to the electrical insurance man who is in a position to know and to appreciate the great chasm between what is, and what should be, and which these "If's" are supposed to bridge!

It is true that standards are constantly being raised and that electrical equipments are being installed in compliance with those higher standards; but the hazard from electrical sources is increasing even more rapidly, and there is a continual overflow, so to speak, which has not been provided against, and which marks the line between perfect safety and danger. When the limit of advancement in electrical science has been reached, when standards are prepared to meet those conditions, and when all electric work is made to conform to such standards, then we may rest contentedly and address ourselves to the simple task of keeping "things in line."

During the year 1902 a total of forty fires was investigated in a certain district, and every one of these was unquestionably due to electric wires or apparatus. Thirty of these fires were directly attributable to the breaking down of the insulation on conductors; six were due to overheating of various devices; one resulted from sparks thrown off from a commutator of an electric motor; one from the ignition of inflammable material by melted fuse-metal from a cut-out; and two were due to crosses on outside wires which came in contact with miscellaneous conductors entering buildings for different purposes. There were many other fires in the same district during that time, which undoubtedly originated from the same source, but, owing to the fact that the fires destroyed all evidence of their origin, it was not possible to definitely ascertain the cause.

It will be seen from this record that the protection afforded to these conductors by the material which is at present placed around them in the shape of so-called "rubber compound" cannot be depended upon to absolutely protect buildings and their contents from damage due to electricity, owing to the natural deterioration to which they are subject. The dielectric, or insulating compound, becomes dry, hard, and brittle and does not any longer resist abrasion nor prevent moisture from getting to the conductors. A flow of electricity, even if slight, over any such material as rubber, wood, and like substances,

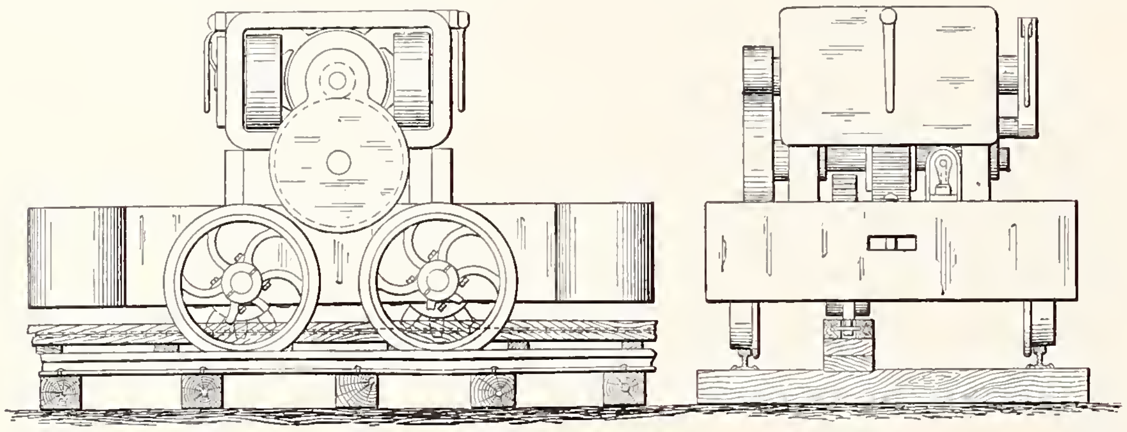


FIG. 24.—A THIRD-RAIL LOCOMOTIVE MADE BY THE GOODMAN MFG. CO., CHICAGO

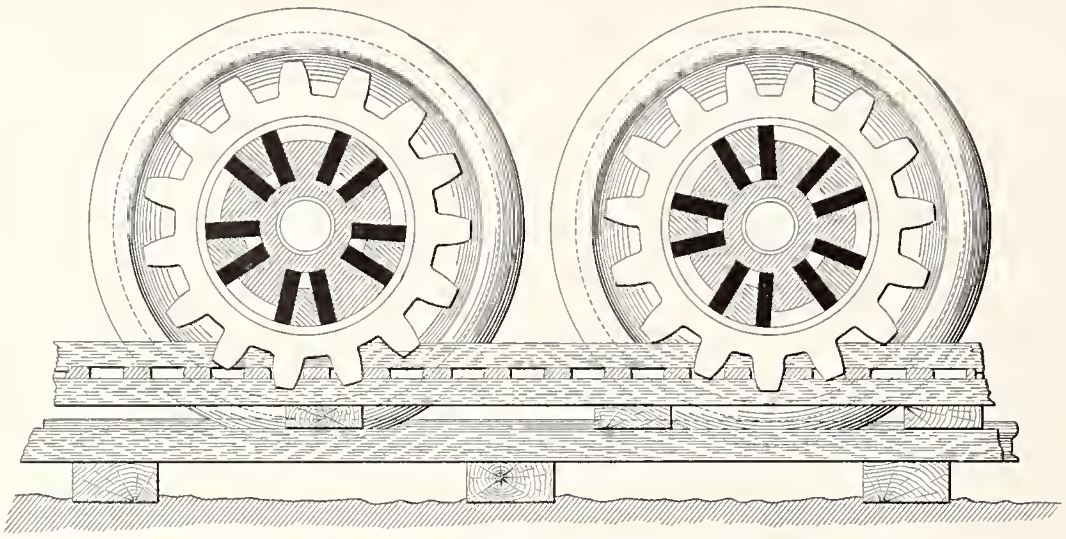


FIG. 25.—THIRD-RAIL AND PINION CONSTRUCTION. SEE PAGE 97

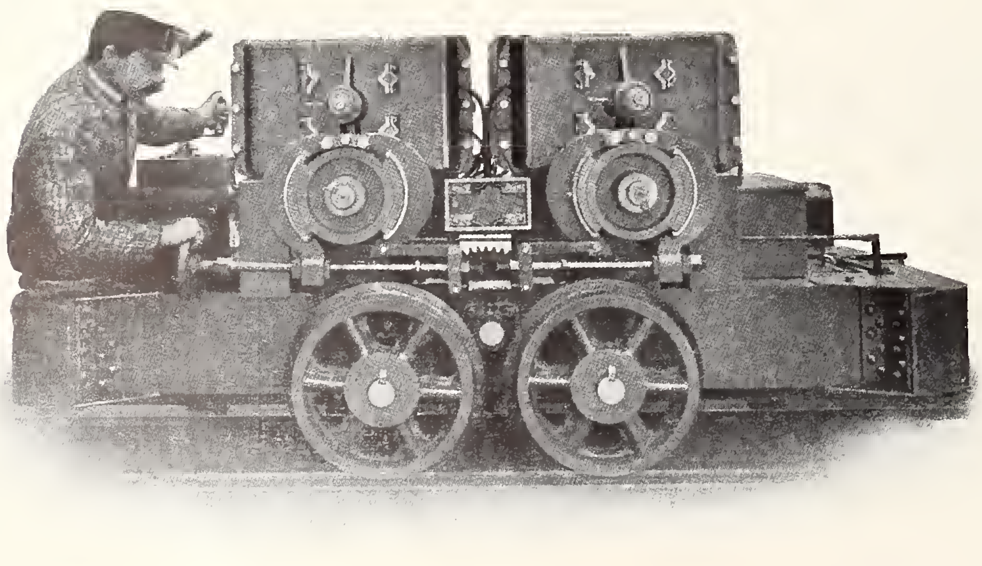


FIG. 26.—A DOUBLE-MOTOR THIRD-RAIL LOCOMOTIVE. SEE PAGE 98

during the presence of moisture, carbonizes the fibre, which thereby becomes a conductor, and, if the electricity continues to flow, the material will, sooner or later, burst into flame.

One of the most difficult things an electrical insurance department has to do, is to prove to the lay mind that an installation which has been in use for several years is in unsafe condition owing to the poor condition of the insulation. The claim is made, and perhaps rightly, that the equipment has not given any great amount of trouble, and it is, therefore, difficult to convince the insured of the possibility of fire from electrical causes, as they fail to appreciate the fact that the efforts of the fire department are directed toward the prevention of fires, rather than in determining the cause no sooner is an equipment completed

The old saying that "familiarity breeds contempt" is most applicable to the average electrical equipment when under the supervision of persons who know nothing of the inherent danger of the system. As a rule, no sooner is an equipment completed than more or less extensive changes and alterations are instituted, these additions and changes being made without any regard whatever to the ordinary precautions which are supposed to be taken in connection with electrical work.

It is a common thing to find on the average equipment, after it has been in service a short time, the panel boards or cut-outs, which, for protection, were encased in cabinets constructed of, or lined with, slate, iron, or similar material, used as storage closets for waste, rags, paper and other combustible things. When the enclosures are too small for this purpose, the doors are either left open or removed, and material of the most combustible nature is stored in direct contact with open fuses, bare busbars and switches.

The ease with which an electric light or fan can be installed at any point in a building, or with which changes can be made in the position of a lamp, using for this purpose a flexible cord and connecting it to the most convenient source of supply, is perhaps one of the most common and flagrant violations of prescribed rules. As it requires but a short time, usually, for the insulation on this cord to become abraded, or so dry and hard as to break at any point where it may be disturbed, it can be seen that this condition is likely to result in trouble at any place on the circuit.

The use of large copper wire and extraordinarily heavy fuses in cutouts, after the fuse originally installed has operated, is on the same order. This can be compared in recklessness only to the tying down of the safety-valve on a steam boiler. A little knowledge of electricity and the laws which govern it in its application to power and lighting systems, well seasoned with ordinary common sense, would enable almost anyone to understand the average precautions necessary in the safeguarding of electrical wiring and apparatus, and if this knowledge, so seasoned, were only occasionally applied, the fire losses from electrical causes would be largely diminished. The following simple rules, if followed, would correct a large percentage of defective electrical work:—

Conductors of any description supplying current for electric light or power purposes should not be permitted to come in contact with metal pipes or other conductors.

All fuses should be stamped or marked with the amount of current in amperes which they will carry without melting, and should not be inserted in a circuit protecting a wire having a safe carrying capacity smaller than the fuse. All fuses should be enclosed in fireproof cabinets unless they are of the plug or cartridge type.

Care should be taken to have all "contacts" on circuits, switches, etc., well secured, as a poor contact always results in heat, which in time will ignite any adjacent combustible material.

A telephone, which is intended for use exclusively in situations where cross-connections may occur between the telephone conductors and high-tension circuits, has been invented by Messrs. Siemens & Halske. The feature of the instrument is that there are no metal parts outside the case which can be touched. Instead, everything is made from either hard or soft rubber, and all the metallic parts of the instrument are contained in a walnut case. The instrument is also provided with high-tension fuses, suitable for 3000, 5000, or 10,000 volts, depending on the voltage used in the station or district in question.

One of the novel features of the equipment of the new White Star Line steamer "Baltic," is her electric heating and cooking appliances. These comprise electric plate warmers, griddles and egg boilers, water heaters and dough mixers. Electric motors, too, are used for driving roasting spits. The whole outfit exemplifies in a very interesting manner how far-reaching the conveniences of electric transmission may be made aboard ships as well as ashore.

Telegraphing in Japanese and Chinese

THE Japanese, like the Chinese, have no alphabet in the ordinary sense, every word of their written language being represented by a separate character. In telegraphing in these languages, therefore, about 10,000 words are selected, and figures ranging from 1 up to 9999 are allotted to each word. Each word of a message to be transmitted by telegraph in these languages is then first given its proper number by the telegraph clerk, by means of a dictionary which has been prepared under the authority of the Government. These numbers are then transmitted by the Morse alphabet, and, when received, the message is translated back into the Chinese or Japanese characters by reference to a corresponding dictionary. This method of telegraphing is, of course, cumbersome, but it could be employed by those nations as the equivalent of a cipher code in warfare, with very little probability of any foreign nation deciphering it. For prompt telegraphic communication, the English language is probably used by the Japanese. For the reasons stated, however, it is obvious that the telephone must be a great boon to nations possessing such extensive alphabets, since by this system each word is transmitted as it is spoken.

Passenger-Carrying Capacities of New York Street Railways

STATISTICS collected by the State Railroad Commission of New York show that for the year ending February 29, the car lines in Manhattan alone carried 670,000,000 passengers, exclusive of transfers; this is more than one million more passengers than all the steam railroads of the United States carried in the same period, their record being 568,000,000 passengers. In Greater New York more than one billion passengers were transported. It is interesting to know of the enormous gain of 37,000,000 passengers on the elevated lines during the year, whereas the surface lines had only a trivial increase of 144,300 This would indicate that the surface lines are working very nearly up to their total capacity.

Tokio, Japan, is to have a steam-turbine railway plant. The Tokio-Shigai Railway Company has ordered four 1500-H. P. Curtis turbines to install in its main generating station. The company is constructing 30 miles of double track, and the cars that are now running take current from the plant of the Tokio Electric Light Company.

Electrolytic Meters

By H. W. YOUNG

FIFTEEN years ago the electricity supply companies of the United States were practically dependent for their meter service upon a device that is now obsolete and regarded more in the light of an interesting curiosity than a commercial meter. This device was known as the Edison "chemical meter," and, while it is true that other forms of meters were being experimented with and also manufactured, none of them could be classed as competitors.

About 1890, however, the "commutator" type of motor meter appeared in a commercial form, and, its superiority being at once recognized, it rapidly displaced the chemical meter, until to-day the latter instrument is found in only a very few of the older stations that have not yet fully converted their service to that of the motor meter.

The advent of the commercial meter marked an era in electric lighting, as it enabled stations that were operating on the flat-rate contract system to adopt the correct system of selling their product by meter, and of thus obtaining a fair compensation for the capital invested. The flat-rate system worked an injustice to both consumer and producer, as it necessitated the establishment of a rate based on the number of lamps installed, instead of on the amount of energy consumed.

The consumer naturally desired to keep his rate as low as possible, and accordingly installed only the number of lamps actually needed in places that had to be illuminated the greater part of the time. Therefore, lamps were not installed in places where they would be used only at infrequent intervals, such as cellars, closets, bathrooms, etc., as the addition of these lamps would increase the rate.

The consumer was thus debarred from the convenience of having lamps in such places as mentioned above, and could not enjoy and realize the great benefit of the electric light.

However, after the lamps were installed, it made no difference in the rate how long they were burned, so that consumers did not extinguish lamps after the actual necessity for their use had ceased, and this long-hour burning resulted in a heavy load on the lighting station at all hours, thus increasing the operating expense and debarring the producer from connecting on much more load than the actual rated capacity of his generators. If more customers were secured, new apparatus had to be installed, thus proportionately increasing the fixed and operating changes.

The meter rate, on the contrary, allows the consumer to install as many lamps as desired, thus greatly increasing the convenience and usefulness of the service. As the consumer, under the meter rate, realizes that his meter is recording all the energy that is being used, he is careful to turn off a lamp when it is not actually needed, thus taxing the generating equipment less severely and permitting the producer to connect up more customers without adding to the station's capacity. The chemical meter was, therefore, an important factor in establishing the proper relation between consumer and producer, and greatly extended the development and value of electric lighting systems.

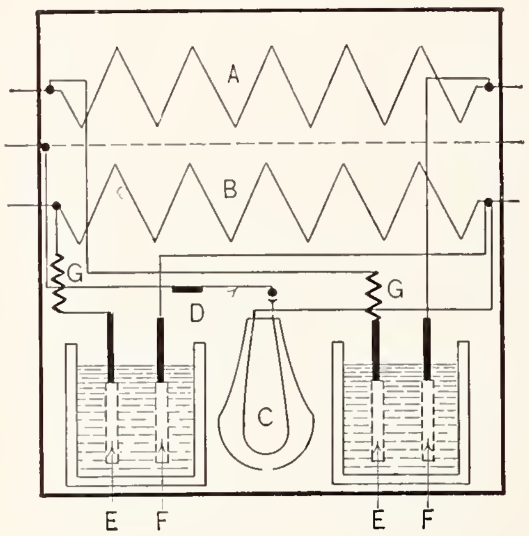


FIG. 1.—A 3-WIRE CHEMICAL METER

In view of the part this device has played in American meter practice, a general description of the meter will be found interesting.

Fig. 1 illustrates the construction of a three-wire chemical meter. This device depended for its operation upon the electrolysis of zinc sulphate with zinc electrodes alloyed with pure mercury. The two shunts, *A* and *B*, composed of metal having a low temperature coefficient, were inserted directly in the outside mains, and the electrolytic cells connected in shunt across their terminals. The value of the current which passed through the cells and the amount of metal transferred from one plate to the other, was directly proportional to the current passing through the main shunts *A* and *B*.

The lamp, *C*, was connected across the neutral and one of the outside mains, through a thermostat, *D*. This thermostat consisted of a thin strip of steel and brass, one end of the strip being securely fastened to the meter case, and the other end containing a contact point free to move. Opposite the contact point on the strip was placed an adjustable screw, carrying a screw contact fastened to the lamp socket, in which was screwed an ordinary incandescent lamp. When the temperature of the meter became low enough to endanger freezing of the electrolyte, the brass, contracting more than the steel, caused the strip to curve and make contact at the two points, thus completing the circuit through the lamp. The lamp then burned until the temperature of the meter case had become sufficiently high, when the strip straightened out, and the lamp was extinguished. By means of the adjustable screw, the distance between the two contacts could be adjusted very closely. A difference of 10 degrees F. caused the contact point at the end of the strip to move about one-fiftieth of an inch.

The solution in the cells was zinc sulphate—this liquid usually being supplied by the meter-manufacturing company. Lighting companies purchased enough solution to last through the winter months, so as to avoid freezing and loss during transit.

The solution was usually changed each month, for, if left for any great period of time, it aged sufficiently to cause the oxidization of the plates, thus increasing the resistance of the cell and causing the meter to under-register. Precaution was taken to keep as much air as possible from the solution by tightly corking the receptacles, for the liquid absorbed air to quite an extent, and thus had a detrimental influence upon the plates.

The plates *EE* and *FF* were cast or rolled of pure zinc, alloyed with approximately 2 per cent. by weight of pure mercury. After a plate had been in use, it was necessary to clean the surface by means of a file or coarse

sandpaper. The negative plate, after a period of service, frequently had a deposit that was not homogeneous with the original metal, and, in such cases, all the granular or loose metal had to be carefully removed before it was again attempted to use the plate.

It was also necessary to amalgamate the plates before installing, by dipping them in a solution of hydrocholoric or sulphuric acid and water, after which the plate was plunged into mercury. Amalgamating had to be carefully and well done, and care exercised to keep the plates clean and free from dust or grease. The plates were held securely in position in the glass jars or bottles by means of a tightly fitting cork, which had previously been thoroughly boiled in paraffine.

The resistance, *GG*, was composed of copper wire and served to compensate for the variation of resistance in the electrolyte, due to changes of temperature. Copper possesses a positive temperature coefficient, while the solution had a negative temperature coefficient.

Just enough copper wire was used to so proportion the total resistance that a balance was maintained under comparatively wide variations of temperature.

It had been determined by experiment that one ampere-hour of current passing between two zinc plates immersed in a solution of the salt of that metal removed from one plate and deposited on the other plate 1224 milligrammes of zinc. In order to obtain this result, it was not necessary that exactly one ampere of current be passed, but it could vary in any manner, provided that the quantity passed, in any given time, be equal to that which would be passed with a current of one ampere, continued for one hour.

The total quantity was found by dividing the number of milligrammes of zinc transferred by 1224. The direction of transfer was always in the direction of current flow—that is, the positive plate lost in weight and the negative plate gained.

The chemical meter had the shunt and the cell resistances so proportioned that for every ampere-hour passing through the meter, one milligramme of zinc was transferred in the smaller size or No. 1 meter, of 10 amperes capacity. The No. 2, or 20-ampere meter, required two hours to transfer 1 milligramme; the No 4, or 40-ampere size, four ampere-hours, and so on with each increase of meter capacity. The constant, or number by which the transfer had to be multiplied, was called the meter "number," and was always equal to the number denoting the size of the meter.

In reading the meter to obtain the amount of current passed, it was necessary to first carefully weigh the positive plate and ascertain the amount of transfer or loss in milligrammes, and, by multiplying this by the meter number, the actual ampere-hours could be obtained. The supply, divided by the current for one standard lamp, gave the consumption in lamp-hours, and, multiplying the lamp-hours by the price per lamp, gave the total amount of the consumer's bill.

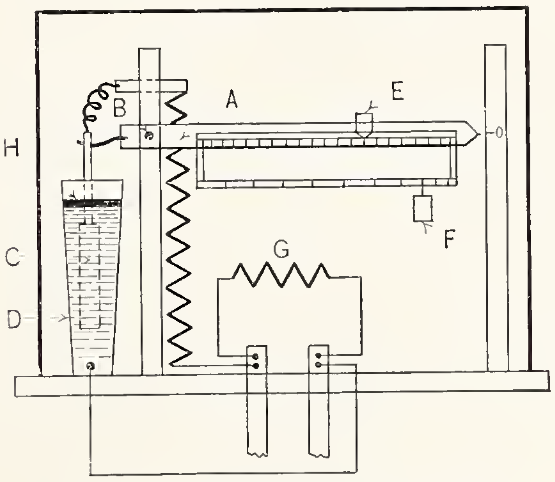


FIG. 2.—A COPPER SULPHATE METER

For example: — Suppose a 10-ampere meter was installed, and, after weighing, a transfer of 3000 milligrammes was shown to have taken place. If the lamp took one-half ampere of current, and the charge per lamp-hour was 1 cent, dividing 1 cent by one-half would give the rate per ampere-hour, or 2 cents. Multiplying the transfer in milligrammes by 2 cents would show the bill to be $60. If the meter had been a 20-ampere size, the ampere-hours would have been 6000, and the bill $120.

It will thus be seen from the foregoing description that a great amount of care was necessary in order to maintain a meter system employing this form of meter, and, even with the best of attention, trouble was sure to develop.

On overloads, or even full loads of considerable duration, the deposit on the negative plate was loose and granular, easily washing off, and even at times dropping down and short-circuiting the cell. This granular deposit, or "smutting" of the plates, as it was called, could be prevented only by frequently changing the cells or installing a meter of larger capacity. Smutting of plates was also greater at low temperatures than at high, so meters frequently had to be installed with a view to the temperature variations of the room.

The solution at times crept up through the cork in the bottle, thus lowering the level of the electrolyte and increasing its resistance. This introduced serious errors, or even short-circuited or shunted the cell.

Internal chemical action frequently took place and resulted in the loss of weight from both plates. This loss greatly affected the lighter load readings, and often introduced excessive errors. Short-circuits on the load side of the meter invariably caused the deposit to fall to the bottom of the cell, resulting in bridging of the plates, and entirely throwing off the registration, thus necessitating an overhauling and replacing of the cell.

The advent of the commutated-motor meter greatly simplified the entire situation, as the registration could easily be interpreted by both consumer and producer, and the meter also required much less attention. However, the electrolytic meter, in one form or other, has always retained considerable favor in England, and has there reached its highest development and refinement. It would be useless to attempt a description of every form of electrolytic meter that has been developed. The writer will, therefore, confine himself to a description of three distinct types, which have proved more or less successful in commercial service.

The form of electrolytic meter shown in Fig. 2 is a development and improvement on the old chemical meter previously described. Its action depends upon the electrolysis of copper sulphate, with copper electrodes instead of zinc sulphate and zinc electrodes. *A* is a suitable lever suspended or pivoted at *B*. *C*, the anode of the cell, is a copper plate suspended by means of a small hook, and held approximately midway in the box, *D*. This box, which serves as the cathode, is also composed of copper and contains the electrolyte of copper sulphate.

E is a small weight arranged to slide over a graduated scale having 100 divisions. *F* is a second weight sliding over a suspended bar, carrying a notched scale, and is exactly ten times as heavy as *E*. One notch of the lower scale is thus equal to the entire value of the upper scale.

G is a suitable high resistance shunt of low temperature coefficient metal, capable of being connected in series with the load to be measured. Flexible connections lead from one end of the shunt, *G*, to the suspended copper plate, *C*, or anode. Another lead is connected to the opposite end of the shunt and to the copper box, *D*, or cathode.

As current passes through the shunt, *G*, a certain amount is shunted through the electrolytic cell, and copper is deposited in the cell from the

anode, *C*, to the cathode, *D*. The anode thus becomes correspondingly lighter, and the system is thrown out of balance. By the adjustment of the weights, *E* and *F*, the suspended parts are brought back to a balance or initial position, and the value of the current consumed is indicated on the two scales. After the maximum scale is reached, or, in other words, the copper plate, *C*, is exhausted, a new plate and copper box must be substituted for the old one. To prevent evaporation, a thin layer of oil, *H*, is placed on top of the solution in the copper box, *D*.

The meter can be calibrated to read in either ampere-hours or, by assuming a constant voltage, in K. W.-hours. While the latter method of calibration is commonly used, it has, however, the disadvantage of being subject to error, due to variations of potential.

While this form of meter has the advantage of simplicity and cheapness, its accuracy is somewhat impaired by changes of temperature and level. Reversal of polarity in this type of meter is quite serious, as it renders the registration wholly inaccurate, a fact which might often be taken advantage of by dishonest persons.

A form of meter, dependent for its operation upon the deposition of mercury from a solution of mercurious salt, has come into quite extensive use within a few years. The several parts of the electrolytic cell are enclosed in a glass tube, hermetically sealed, and supported in a suitable case. Advantage is taken of the fluidity of the mercury to measure the volume instead of the weight of the metal deposited.

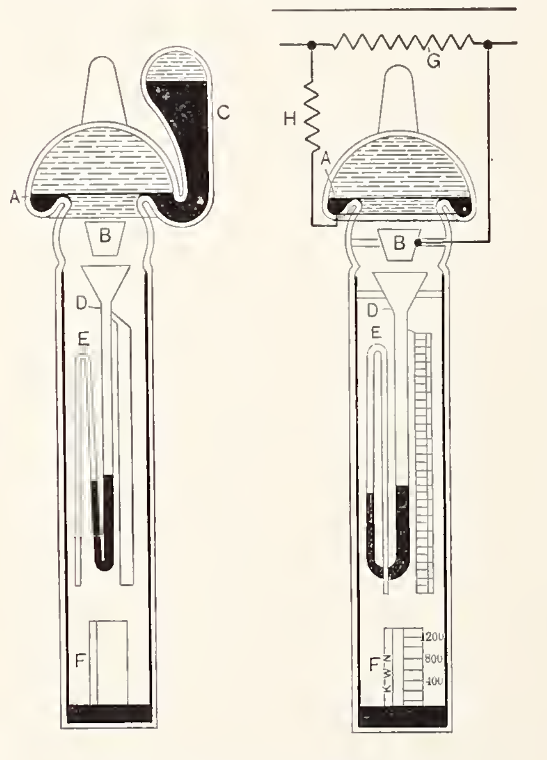
Figs. 3 and 4 illustrate the construction of the meter and show the disposition of the various parts. The anode of the cell is shown at *A* and the cathode at *B*. The mercury of the anode is contained in a circular trough, from which it is deposited upon the cathode, *B*. As mercury is deposited from the circular trough, a fresh supply flows from the anode feeder, *C*, and thus keeps the mercury at a proper level.

As will be seen from the illustration, two fixed scales are provided, the upper scale having a maximum of 100 K. W.-hours and the lower scale a maximum of 1200 K. W.-hours. After the mercury from the anode, *A*, has been deposited on the cathode, *B*, it drops, in the form of small globules, into the glass tube, *D*, which opens out at its upper extremity into a glass funnel, so arranged that all mercury dropping from *B* must be indicated.

When the tube, *D*, becomes full, or, in other words, when 100 K. W.-hours have been consumed in the lamps or other current-using devices, the mercury will stand at a level a trifle higher than the bend in the siphon tube, *E*. The mercury is then at once siphoned off into the lower or larger tube, *F*, attached to which is the second scale, having a maximum of 1200 K. W.-hours. The tube, *F*, is so graduated that one division on its scale is equal to the complete volume of mercury in *D*, or, in other words, 100 K. W.-hours.

When the tube, *F*, becomes full, it is necessary to reset the meter—that is, return the mercury to the feeder chamber, *C*. Resetting is accomplished by inverting the entire tube, which permits the mercury to return to its original position. In the commercial form of meter this is accomplished by mounting the tubes on a hinged support, so that they may be tipped up, and, after the mercury has returned to the chamber, *C*, the tube is brought back to its initial position.

Owing to the fact that the electrolyte has a negative temperature coefficient, changes of temperature would introduce serious errors if this were not compensated for, as the relation between the current in the shunt, *G*, and the current in the cell would be a variable quantity. To counteract the effect of temperature change in the electrolyte, which has a negative coefficient, a copper resistance wire, *H*, having a positive coefficient, is inserted between *A* and one end of the shunt, *G*. The combination of these two elements in correct proportions will result in making the total resistance of the shunt circuit practically constant at all temperatures.



FIGS. 3 AND 4.—A METER OPERATING BY THE DEPOSITION OF MERCURY

This form of meter is of cheap construction, easily taken care of, and free from many of the objections found in the older forms. At light loads errors are apt to be introduced, due to the adhering of mercury to the cathode, *B*. The drop of potential in the meter is often considered objectionable, and the fact that, by reversing the connections at the binding posts, it is possible to throw the meter out of registration, is a most serious objection.

At low temperatures the electrolyte is liable to freeze, although in many installations this trouble would not be experienced. In the manufacture of meters of this type, great care must be exercised to use only chemically-pure mercury and mercurious solution that has been thoroughly cleansed.

The device, while primarily an ampere-hour meter, is usually calibrated at a given voltage, and thus made to register in K. W.-hours. While this calibration allows the meter to be read in standard units, still it is open to objection to the extent that errors in registration are apt to be introduced by voltage vibrations.

An electrolytic meter dependent for its action on the electrolysis of water is shown in Fig. 5. This meter depends for its operation on the fact that the quantity of gas liberated, or volume of water decomposed, by the passage of the electrical curent, is directly proportional to the amount of current flowing.

The construction of the meter, as will be seen from the illustration, is extremely simple. *A* is a suitable glass vessel, terminating at the upper end in an open tube. *B* is a hollow vulcanite box, having two vulcanite tubes, *D*, *D*, extending up through, and projecting beyond, the top of the glass tubes. As will be seen from the illustration, the box, *B*, also serves as a support for the two electrodes, *C C*. Conducting wires are fastened to these electrodes, and, passing up through the vulcanite tubes, they are fastened to the binding posts, *E*, of the meter. The entire construction is held in place by means of a cap, *F*, through which the vulcanite tubes pass.

In the center of this cap, *F*, is fastened a glass funnel, *G*, through which the electrolyte is poured. The glass vessel, *A*, is nearly filled with electrolyte, which is a very dilute solution of sulphuric acid and water, to which is added a non-freezing mixture. On top of the electrolyte is poured a small amount of paraffine oil, *H*, to prevent evaporation. The oil and electrolyte form a sharply defined line, as shown in the illustration.

The action of the meter is as follows:—As the current passes from one electrode to the opposite one, it decomposes the water in the solution,

and the hydrogen and oxygen gases evolved escape up the vulcanite tubes into the outer air. The level of the electrolyte in the glass tube is, therefore, gradually reduced, this reduction being proportional to the amount of current which passes.

A more or less accurate means is thus provided to indicate, on a properly placed scale, the quantity of current which has been consumed. The readings of the meter are taken at the line formed by the junction of the oil and the electrolyte.

It will be noted that the scale, which is divided into K. W.-hours, has its zero reading at the top and the maximum reading at the bottom of the scale. When the electrolyte reaches the maximum scale reading, fresh water is poured through the glass funnel, *G*, until the solution reaches the zero mark on the scale.

Ageing of the electrolyte takes place after a certain amount of current has passed, and its conductivity is, therefore, increased. The resistance of the electrolyte thus constantly tends to decrease; but, as all the current passes through the meter, no shunt being employed, the decrease of resistance does not affect the meter's accuracy. The absence of a shunt also frees the instrument from errors due to polarization and back electromotive forces.

This electrolytic meter is reasonably accurate at different points of the curve, and the registration is unaffected by vibration—a cause of complaint in some meters of the motor type. Heavy overloads may be applied for some time without danger of damaging the meter, although a fuse is usually inserted to protect it from excessive overloads due to short circuits. The action of the meter cannot be reversed, or, in other words, cause backward registration, and thus it may be connected in the circuit without regard to polarity.

The meter, however, has a high drop or loss of potential, which, in many cases, would be quite objectionable. This is particularly true of incandescent lighting circuits, where the candle-power of the lamps is seriously influenced by a change of voltage.

Owing to the fact that the meter has to be periodically refilled with water, it is obvious that the past record is entirely destroyed at each renewal. In case of a dispute between consumer and producer, this destroying of previous records might easily lead to trouble, for it would be impossible to check up the consumption, as in a meter having a higher-reading register. In a case like that cited above, the operating company would probably have to stand the loss or antagonize the customer.

The fact that the meter, in order to read in K. W.-hours, has to be calibrated at a given potential, is, in many cases, an objection, as variations of potential will introduce errors to a greater or less extent.

The meter is suitable for direct-current, two-wire service only, and cannot be used on alternating current. For three-wire service, one meter is inserted in each of the outer mains, the two elements being contained in a single case. Large capacity meters cannot be made in this type, the average capacity being about 5 amperes, and even in this capacity the drop is rather high, and would probably be too great for many installations.

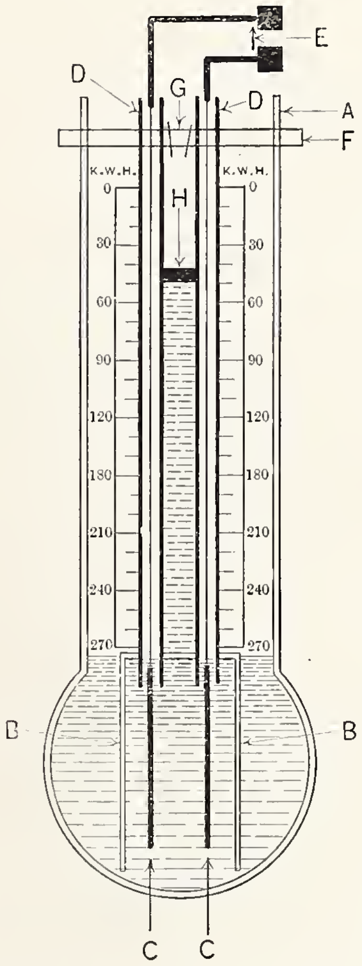


FIG. 5.—A METER OPERATING BY THE ELECTROLYSIS OF WATER

A trouble frequently met with in this form of meter is that the gases are liable to explode. These explosions may be caused by sparking between the terminals when the solution reaches a low point, or by ignition from the flame of a candle or match. Such explosions usually destroy the glass structure, and are also a source of danger to persons in the vicinity.

The fact that meters of this class employ glass structures, which are inherently weak and liable to breakage, renders them extremely susceptible to damage during transportation or installation. Breakage of the glass receptacle at once renders the meter unfit for service, and necessitates the installation of a new one.

In view of the development in the three types of meters described above, which have attained considerable popularity in England, it might be well to consider the chances this type of meter has of again entering the American meter field.

The new and improved forms are, unquestionably, much superior to the electrolytic meters formerly used in the United States, and this, coupled with the fact that they can be made and sold at lower prices than motor meters, would naturally give them consideration. However, notwithstanding their low cost and improved construction, it does not appear that the conditions in the United States will warrant their adoption.

The electrolytic meter is suitable for the measurement of direct current only, and this would, in many instances, be a great objection, owing to the fact that a large number of electricity supply companies operate both alternating and direct-current systems. The commutator type of motor meter is suitable for use on either alternating or direct current, and thus enables a station to carry one type of meter, suitable for all its conditions. If the electrolytic meter were adopted for direct-current service, it would necessitate using a motor meter for the alternating-current service, thus adding to the expense, and making the stock of meters less flexible and mobile.

The standard units in the United States, on which charges are based, is the watt-hour and K. W.-hour, and, as an electrolytic meter is strictly an ampere-hour meter, it would not be applicable to existing systems. It is true that this might be overcome by calibrating the meters for constant voltage, and enable them to be read in K. W.-hours, but this at once lays the registration open to serious error, owing to voltage variations. Even a great many meters calibrated for the given operating voltage would not be applicable to an entire system, as the voltage of every system is somewhat different at the various points of supply. The motor type of meter, on the other hand, registers in watt-hours or K. W.-hours, and is, therefore, independent of ordinary voltage variations.

The high drop usually found in electrolytic meters would be considered an objection in the United States, and is one which, apparently, cannot be avoided. This is not so important in England, as the use of 220-volt lamps permits of smaller capacity meters, but with the 110-volt systems employed in the United States, larger ca-

pacity meters would be necessary, and the drop of potential would be a serious matter.

Freezing of the solution would, in many parts of the country, be a common cause of complaint, as the temperature in many places falls extremely low during the winter months. Motor meters are, on the contrary, practically independent of temperature variation, owing to the fact that the potential circuit and retarding disk have the same temperature coefficient, and any change of temperature affecting one element affects the other element to the same degree.

Reversing the polarity of the system has no effect on the reading of the motor meter, but is fatal to the registration of electrolytic meters. This objection is very serious, as it would afford a great opportunity for dishonest persons to commit fraud and deprive the operating company of its just revenue.

As electrolytic meters contain considerable glass in their construction, it makes them extremely fragile and liable to damage during transportation or installation. Meters receive a great deal of rough handling before they are finally installed on the consumer's premises, and, as any breakage of the glass tubes or bulbs at once renders the electrolytic meter unfit for service, it will be readily seen that a large item of expense would be introduced, to say nothing of the inconveniences caused by the loss of the meter. The acids and mercury used in electrolytic meters would also be a source of danger to other materials and apparatus.

In considering the chances of breakage in meters, it must be borne in mind that the United States is a country of great distances, and that with increasing distance between the manufacturer and the electricity supply station, the danger of breakage in transportation is correspondingly increased. Shipping meters any great distances would be a difficult problem, and the breakage of tubes would entail heavy transportation charges, in addition to the expense of new meters.

The motor type of meter, on the contrary, is of extremely rugged construction, and is seldom injured in transit or during installation. Even if, by any chance, one or more of the elements be injured, or even destroyed, new parts can be easily obtained from the manufacturer, and the meter repaired and put in operating condition with little trouble or expense.

After a careful consideration of the merits and demerits of both types, it appears that in spite of its popularity in England, the electrolytic meter will never obtain any large or permanent foothold in the United States, or prove a serious competitor to the motor type of meter. However, owing to its inherent simplicity and cheapness of construction, the electrolytic meter will, undoubtedly, always continue to be a subject of interest to the inventor, manufacturer and central station manager, all of whom will welcome any improvements which will add to its reliability and usefulness.

Electric Lighting and Criminality

ELECTRICITY does not complete its function in supplying light to the home; perhaps it serves a greater purpose in supplying light outside the home. The conditions existing in a great city, says "Electricity," are so varied and complex that at night, while millions are at rest, the sneak thief, the burglar, the thug and other night birds could work undisturbed in many quarters were it not for the electric light.

Police Commissioner McAdoo, of New York, referring to this subject, recently remarked:—

"I have always believed that light would prevent a great deal of disorderly conduct at night in certain streets. I do not believe there is anything that would rid us of illegal resorts and clean up certain streets as would light. If they were to give me the charge of lighting New York as well as protecting New York I would at least double the light.

"I know of a place here before which a big light was put. The proprietors practically got down on their knees to have it removed. I would apply the light remedy."

The Chelsea Power Station of the Underground Electric Railways Company, of London, is a 175 x $453\frac{1}{2}$-foot building, with a 25 x 81-foot annex. It will have ten 5500-K. W. units and one of 2500 K. W. Three-phase 33 1-3-cycle, 11,000-volt current will be distributed from the station to twenty-three substations. The steam equipment is arranged on the group system, each group comprising a turbo-generator, eight boilers and a feed pump. The steam piping of the groups is not connected except at one end of the building, where three groups are joined by a small auxiliary header for supplying exciters, air-compressors and other minor machines. Including the office building, the plant will furnish 1 K. W. per 1.35 square feet, or per 139 cubic feet.

Sir Oliver Lodge on Lightning

IN a lecture experiment to show the action of lightning and lightning conductors, says "Electricity," of London, Sir Oliver Lodge lately represented the electrically-discharged cloud by a thin sheet of metal mounted on non-conducting standards and charged from the battery at pleasure. This "cloud" sloped downward from front to back, so that the distance of conductors from the under side could be varied by sliding them over the table.

Copper, iron, and wet string were tried as conductors, and all proved efficient, although the copper was the most intense and rapid, producing a sharp crack at the flash, while iron gave less noise, and the wet string hardly any. Prof. Lodge holds that iron is as efficient a conductor as copper, with less tendency to set up the side-flash that in most protected buildings has caused the lightning accidents.

He divides lightning into two kinds —the first being the normal discharge from an overcharged cloud to the earth, and the second occurring when a large cloud discharges into a smaller one, generally below it, suddenly overcharging the small cloud, and causing it to discharge violently to earth. The second form, more sudden and violent than the first, is much more difficult to guard against.

Testing Electric Locomotives

THE New York Central & Hudson River Railroad is building near Hoffmans, N. Y., a substation and transformer, to be used for transforming alternating current for use in the tests to be made this fall of the new electric locomotives for hauling trains in and out of the city of New York. The current will be of 10,000 volts, from the General Electric Company's plant in Schenectady, N. Y. For about 8 miles at Hoffmans the old freight tracks are to be made suitable for the operation at a high rate of speed of the new locomotives. It is expected that the first test will be run in October.

The forthcoming report on the country's coal production, made by Mr. Edward Wheeler Parker, statistician of the United States Geological Survey, shows that 359,421,311 short tons of coal were mined in this country in 1903, an increase of 57,830,872 short tons, or 19 per cent. over the production of 1902. Of the total production, 74,313,919 tons were of Pennsylvania anthracite, an increase of 33,940,324 tons, or 44.3 per cent.

New Applications of Electric Motors at the St. Louis Exposition

By CLOYD MARSHALL

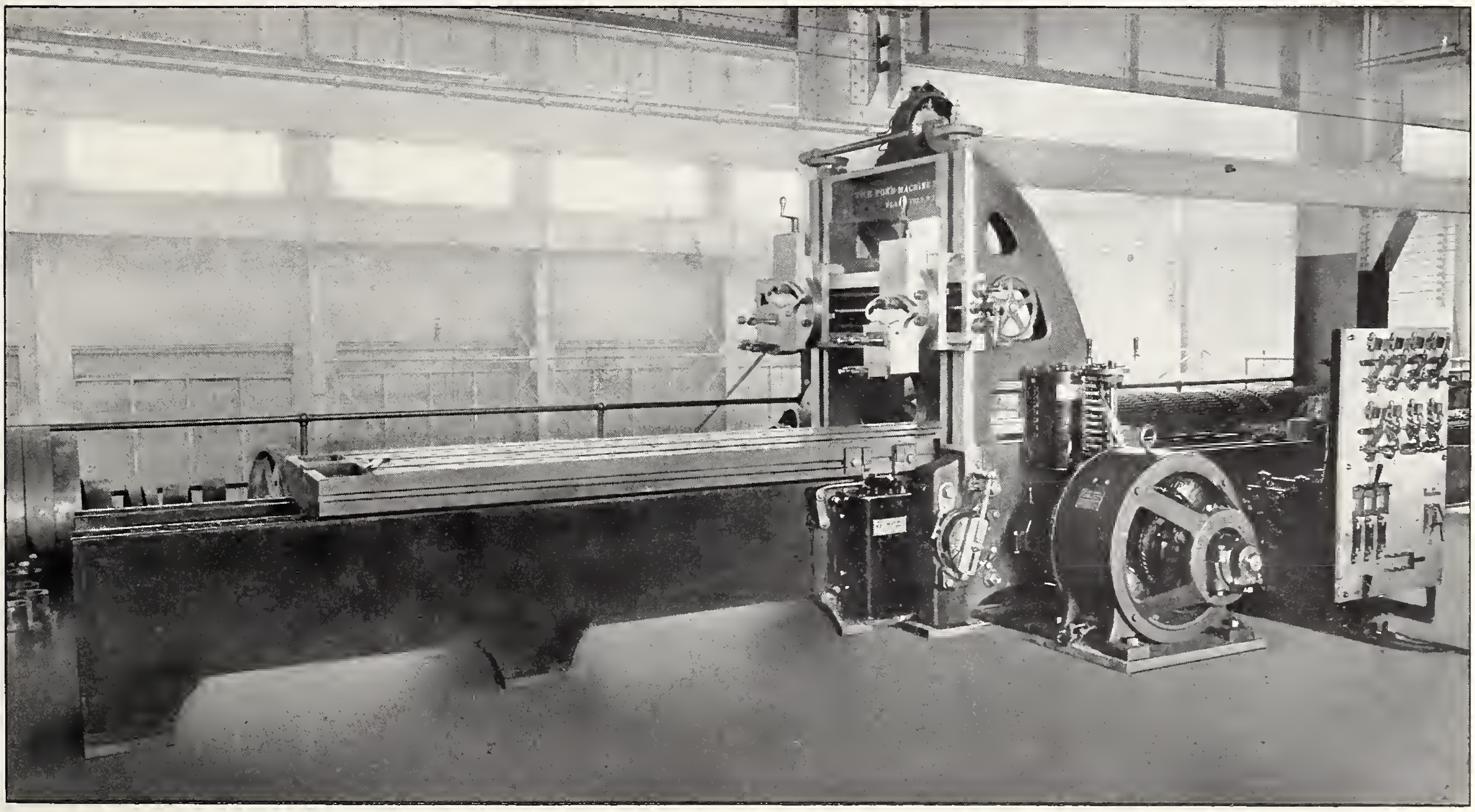
THE use of electric motors for all power purposes has expanded so rapidly that it has been difficult, even for those directly interested, to keep in touch with the latest developments. The ingenious application of motors to tools and machinery resulted mainly from the efforts of electrical engineers and manufacturers, and, until recently, this has been done without the co-operation of tool makers. Objections were raised to changing designs and patterns so that the motors might be most advantageously placed for driving purposes. Later, with chain gear or direct connection, the driving power was so increased that the machinery had to be altered and strengthened, and in this way the motors have become more nearly an integral part of the tools.

In the Electricity Building at St. Louis the electrical manufacturers are exhibiting the most recent adaptation of their motors to tools and machines. Wherever power is required, whether it be for a sewing machine or for pumps taking 2000 H. P., the motors have been perfectly designed for their work. In fact, it might be said that the display of electrical apparatus covers all parts of the Exposition, for the work, whether in the exhibit palaces, the mining gulch, the cascades or on the Pike, is done by means of electric motors.

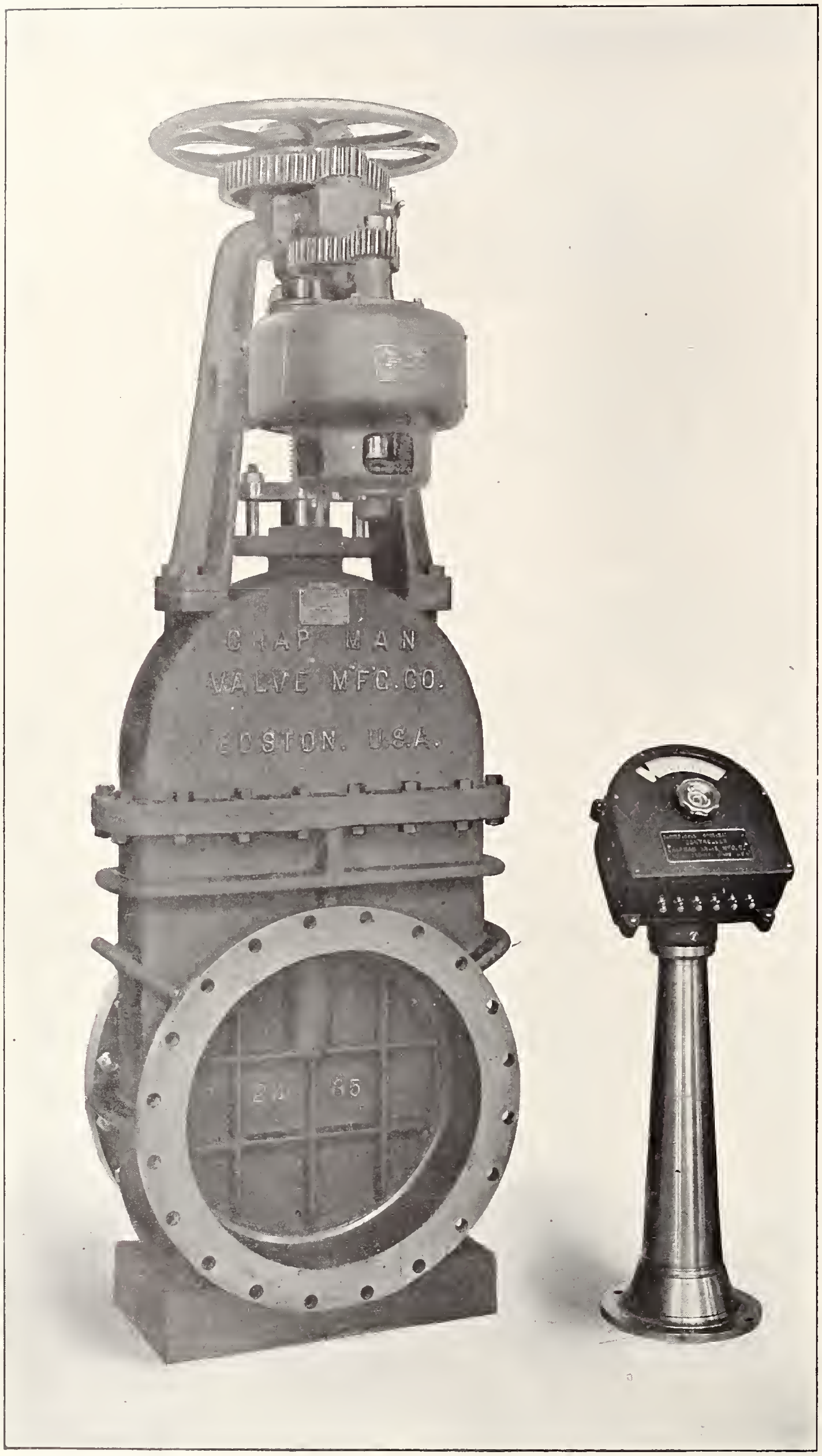
The widening adaptation of electric motors to every kind of tool developed such varying conditions that the electrical engineer had to make the motor a most versatile machine. There are at least four general divisions of work in which the motor is now performing faithful service. Where the requirements are for a fixed speed independent of the load, a shunt-wound, direct-current motor is suitable on account of its automatic regulation of speed within close limits. For cranes, hoists and other machinery requiring frequent starting and stopping under load, the operation being at all times directly under control of an attendant, and where constant speed is not necessary, a series-wound motor is especially fitted. This has the further advantage of a strong starting torque with a relatively small current, and high speeds at light loads and slow speed under a heavy load.

Another class of machinery requires only approximately constant speed with sudden and wide variations of load, or necessitates frequent starting or changing the direction of motion of a mass having great inertia, as, for example, elevators, punches and printing presses. For this work a compound motor is suitable, as it combines the characteristics of the strong starting torque of the series motor with an approximation to the automatic regulation of a shunt motor.

Another group of machines which is a rapidly growing one requires for economical operation a great variation in speed with the heaviest torque at slowest speed and a less torque at higher speeds, the actual rate of work remaining about the same at all speeds. Drills, lathes, boring mills,



A WESTINGHOUSE MOTOR DRIVING A PLANER MADE BY THE POND MACHINE TOOL COMPANY, PLAINFIELD, N. J.



AN ELECTRIC MOTOR-OPERATED GATE VALVE. THE MOTOR IS OF THE GENERAL ELECTRIC COMPANY'S MAKE. THE VALVE WAS MADE BY THE CHAPMAN VALVE MANUFACTURING COMPANY, BOSTON, MASS.

and a wide variety of machine-shop tools belong to this group. For such work the variable-speed motor, operated by means of a multi-voltage system, field control, and a combination of armature windings, is especially suited for this work. The direct-current motor and system have been highly developed to meet all these exacting conditions, and, while the alternating-current apparatus is not so well adapted to all the different requirements, yet the manufacturers have been constantly widening the special fields for this class until to-day the largest motors built are of the induction type.

Examples of machine tools coming under each of the different classes enumerated may be found in the local shops of any industrial center, but a number of new ideas in motor drive have been recently developed, and advantage has been taken of the World's Fair to show ingenious adaptations of motive power.

The line of motor-driven machine tools exhibited by James Clark, Jr., & Company represents a new departure in the application of motors to machine-tool drive. Instead of attaching a motor to a machine through a combination of belts, gearing or speed boxes, a special variable-speed motor is embodied in the design of the machine itself. The symmetrical appearance and ease of operation fully demonstrates the advanced step in machine-tool design taken by the makers of these machines.

The illustration on page 113 shows a radial drill of this type, one of three sizes built by the company. The location of the driving motor on the head of the drill allows the power to be applied direct to the spindle without loss; it is simple and compact as can be made, and all parts needing attention are easily accessible for examination and adjustment. The motor frame is cast into the head of the machine and is directly geared to the spindle. It has a multipolar field, iron-clad armature, self-feeding carbon brushes and self-oiling bearings. It is made with two commutators in order to get a wide speed regulation with high efficiency on any speed. The motor has nine speeds which, in connection with the back gears, give 18 spindle speeds, from 14 to 250 revolutions per minute in geometrical progression.

The motors are built to operate on single-voltage circuits, the speed changes are accomplished without armature resistance, and the motor runs at practically constant speed for any load in any position of the controller. This feature of speed regulation on a single-voltage circuit is a very valuable one, as it enables this tool to be used in any shop having either the single or multiple-voltage distribution. The back gears are of the friction type, and can be thrown in or out while in operation. The spindle has a quick return, a depth gauge, which can be set to automatically trip at any depth desired, an automatic stop and eight positive feeds from .006 to .62 inch per revolution in geometrical progression. The spindle is a crucible steel forging, ground to size and fitted

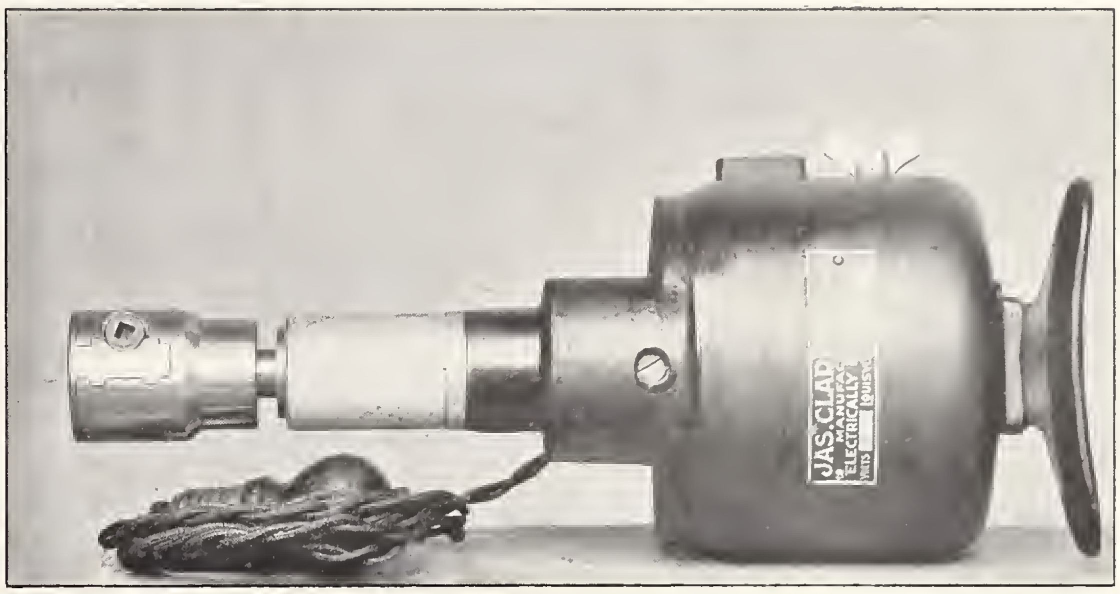
with a friction-geared tapping attachment, which is positive and can be operated while the spindle is in motion. All the operating levers are located on the head within easy reach of the operator.

The arm is of the most rigid construction, strongly gibbed to the column, and is raised and lowered by a plain series-wound motor in the top of the column. It is directly geared to the hoisting screw and is controlled by a small handle on the side of the column. The column swings on a central stump with ball bearings at the top to take the weight, and roller bearings at the bottom. By means of an adjusting screw the column can be raised to just clear the base, the weight of the column and arm being thrown on the ball bearing, in which position it swings very freely. A clamping lever is arranged to transfer the weight from this bearing to the base of the machine and to clamp the outer column to the bed at the outer edge of the column base. There are only two joints in the drill between the base and the head when clamped in position for work, and at both these joints the parts in contact have very large bearings, insuring the utmost rigidity for heavy work. The machine is regularly equipped with a compound table having a tangent screw.

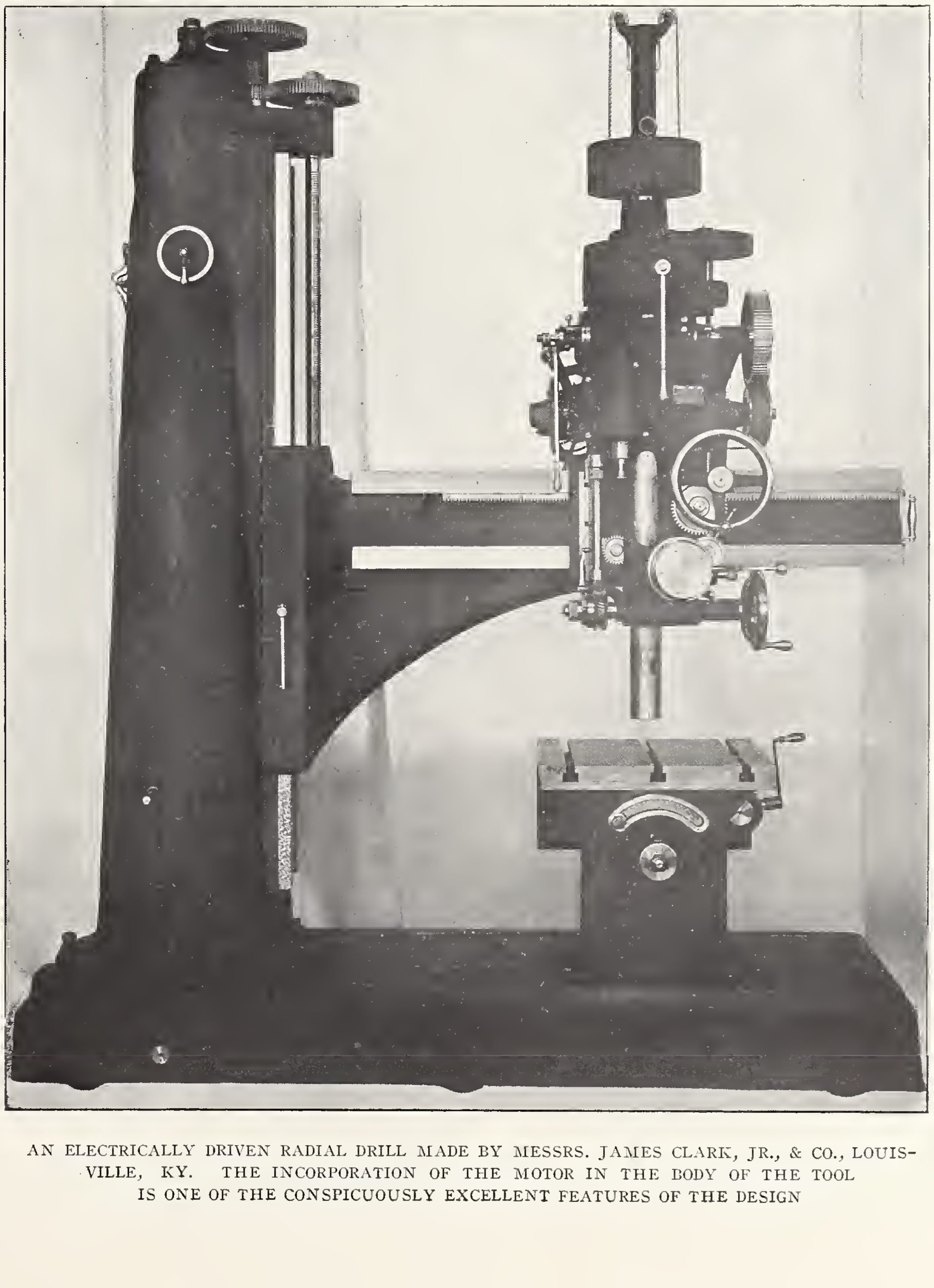
The breast drill shown on this page is another product of this company. The tool is designed for drilling small holes, replacing hand or small pneumatic drills. Power can be applied wherever there is an incandescent lamp socket. There are two sizes, wound either for 110 or 220 volts, direct current. No. 1 will drill holes in iron up to $\frac{3}{8}$-inch in diameter, and requires $\frac{1}{8}$ H. P. The drill weighs 15 pounds. No. 2 takes 1-6 H. P., weighs 22 pounds, and will drill a hole $\frac{3}{4}$-inch in diameter. All of these motor drills are in full operation in the southwest corner of the Electricity Building.

In the past the planer has been one of the least efficient metal-working tools. With the belt drive only a single cutting speed has been provided, this speed in general being too low for cutting cast-iron at maximum efficiency, and too high for cutting steel without very rapid depreciation of the tool. With the motor-drive in connection with clutches, this condition has been relieved somewhat by the introduction of change gears between the clutch which imparts the cutting motion and the driving shaft of the planer, thus rendering available two or three cutting speeds. This arrangement, however, is more or less complicated and expensive, requiring considerable time for adjustment of the gears, and in general does not provide a sufficient range of cutting speeds.

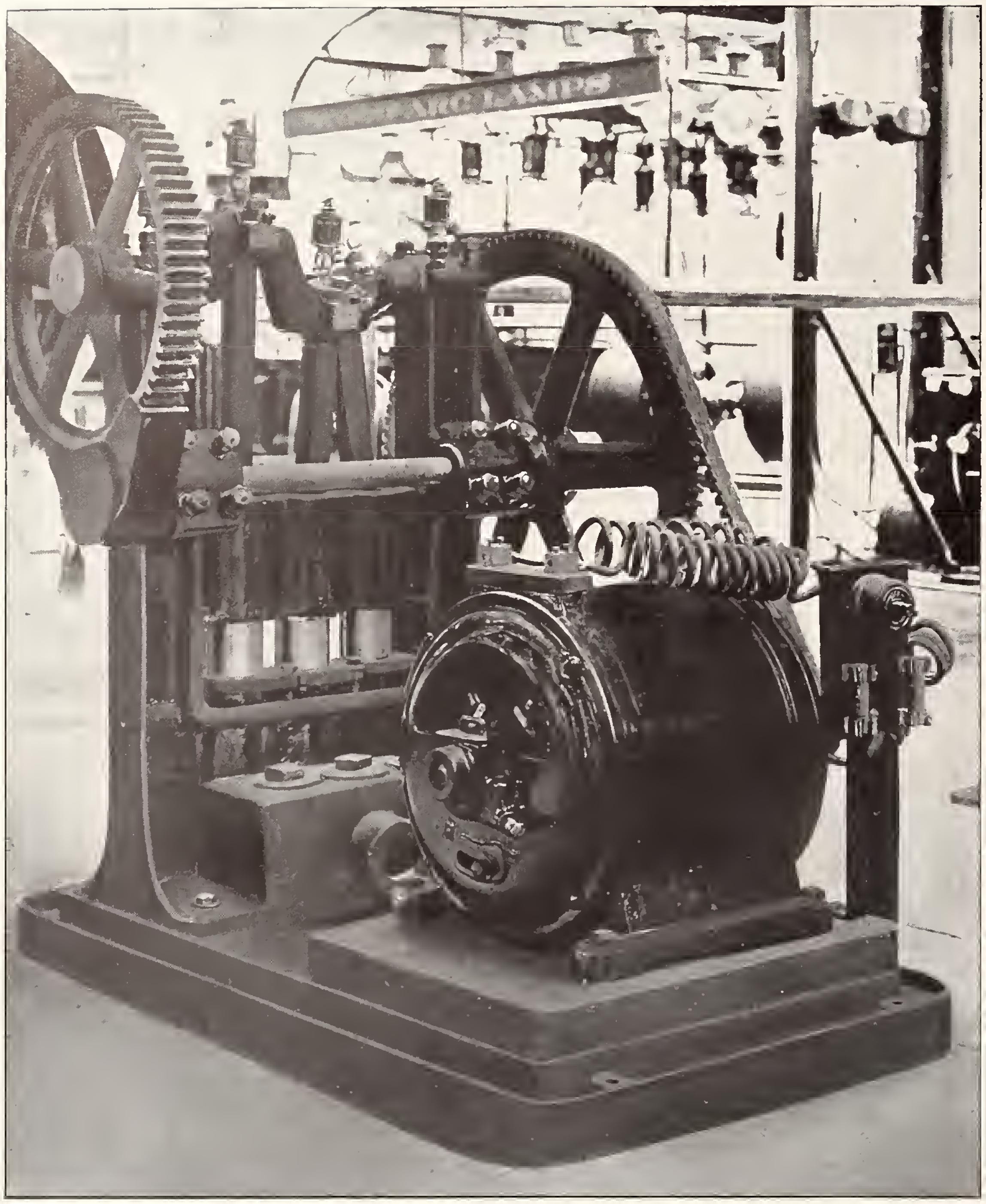
The Electric Controller & Supply Company have developed a direct-connected motor-drive which gives a number of cutting speeds, and these are instantly available by a simple operation of the controller. By this means the cutting speed may be instantly and accurately adjusted for securing maximum cutting efficiency



AN ELECTRIC BREAST DRILL MADE BY MESSRS. JAMES CLARK, JR., & CO.



AN ELECTRICALLY DRIVEN RADIAL DRILL MADE BY MESSRS. JAMES CLARK, JR., & CO., LOUISVILLE, KY. THE INCORPORATION OF THE MOTOR IN THE BODY OF THE TOOL IS ONE OF THE CONSPICUOUSLY EXCELLENT FEATURES OF THE DESIGN



A SINGLE-PHASE MOTOR MADE BY THE WAGNER ELECTRIC MANUFACTURING COMPANY, ST. LOUIS, MO., DRIVING A TRIPLEX PUMP

with any material to be worked. The planer is direct-driven with a variable-speed motor without the use of belts or clutches, the motor being, wherever possible, directly coupled to the cross shaft of the planer. By means of a reversing switch, operated by dogs adjustably mounted on the platen of the planer, and an automatic controller, the motion of the driving motor is reversed at either end of the stroke. An operating controller is provided, by means of which the speed of the motor, in the cutting direction, may be accurately regulated. The automatic controller is so arranged that, on the cutting motion at each stroke, the table on the planer will be automatically accelerated to a speed determined by the operating controller, and, on the return, the table will in general be accelerated to maximum speed, as it is, of course, desirable that the table be returned as rapidly as possible on the idle stroke.

Where desirable, however, as in the case of planers which cut in both directions, the controller may be so arranged that the speed in either direction may be varied at will. The operation of the controller is such that the driving motor will reverse and accelerate the platen of the planer just as rapidly as is consistent with the power of the motor. The maximum current which can flow to the motor is absolutely limited, so that there is no sparking or undue mechanical straining at the instant of reversal. The platen may be reversed by hand through the operation of a shifter attached to the reversing switch. When the shifter is brought to the central position, the platen is instantly stopped. The operating controller is provided with a notched dial which plainly shows the cutting speed, and the automatic controller requires no attention whatever from the operator.

Planers equipped with this form of drive have thoroughly demonstrated, not only the practicability of the system, but also its very pronounced advantages in increased output of the tool, superior accuracy of stroke, low cost of maintenance, simplicity and compactness. In the exhibit space of the Electric Controller & Supply Company a Pond planer is driven by a Westinghouse motor, and shows the operation of cutting iron and steel surfaces. A planer of this type is shown on page 111.

The ever-increasing magnitude of the power plants now being constructed, requires steam and water valves of large proportions, too big to be operated conveniently by hand. Hydraulic, pneumatic and steam-operated valves have by experience been proven unsatisfactory for all purposes and pressures, but with the steadily increasing application of electricity to all kinds of machinery, a large demand has arisen for valves to be operated by electric motors.

The merits of the electric motor as a means of supplying power for a multitude of purposes have led the Chapman Valve Manufacturing Company to adopt this method of operating valves and sluice-gates. This development practically solves the problem of the rapid handling of large gate-valves, under ordinary conditions and especially in cases of emergency.

In the designing of such apparatus, the conditions governing the application of the electric motor to the valve were found to differ entirely from the application to all other machinery, inasmuch as the travel is, of course, limited to the size of the valve opening. The problem presented was overcome by the use of a motor especially adapted for the purpose, and a lost-motion device enabling it to attain practically a runaway speed, as it is series wound. Valves of this class are especially suited for water, steam and oil lines, and for low-pressure work, such as exhaust and condenser piping, pump-suctions and discharge sewerage, and irrigation systems. They are also extensively used on the receiver piping of compound and triple-expansion engines, and are rapidly coming into use as throttle valves on steam turbine units.

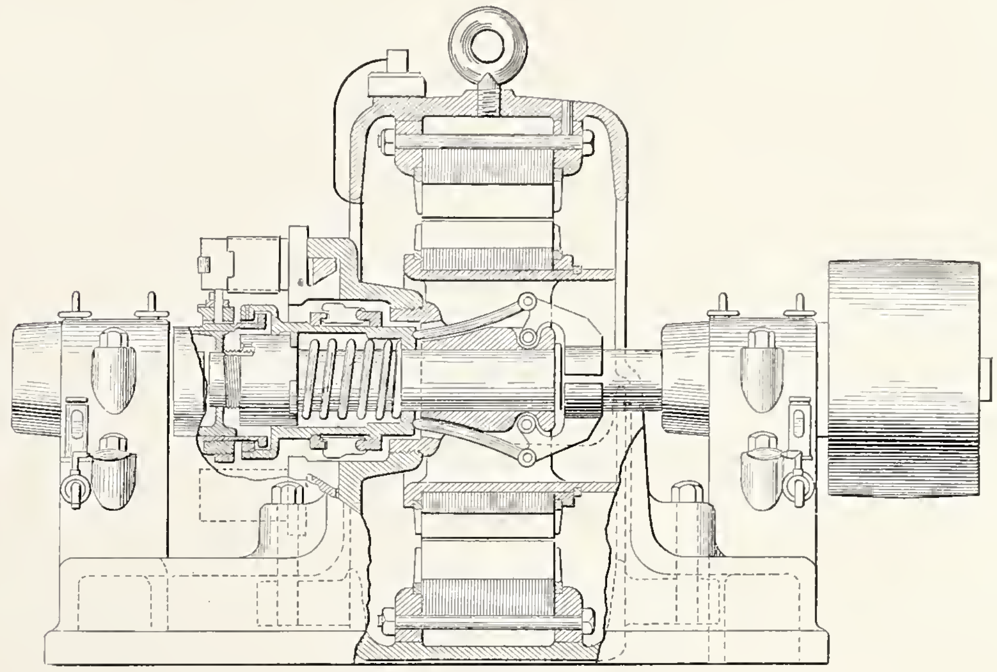
The Chapman gate valves are of the double-faced, solid-wedge, plug type, and have a straightway passage the full diameter of the connecting pipe. This is the simplest and strongest design for the purpose. It requires the smallest number of working parts, and offers the least resistance to the passage of the fluid. The compactness and simplicity in construction of the valves enable the use of a very small motor for their operation. However, the motors are amply large to open the valves under all conditions,

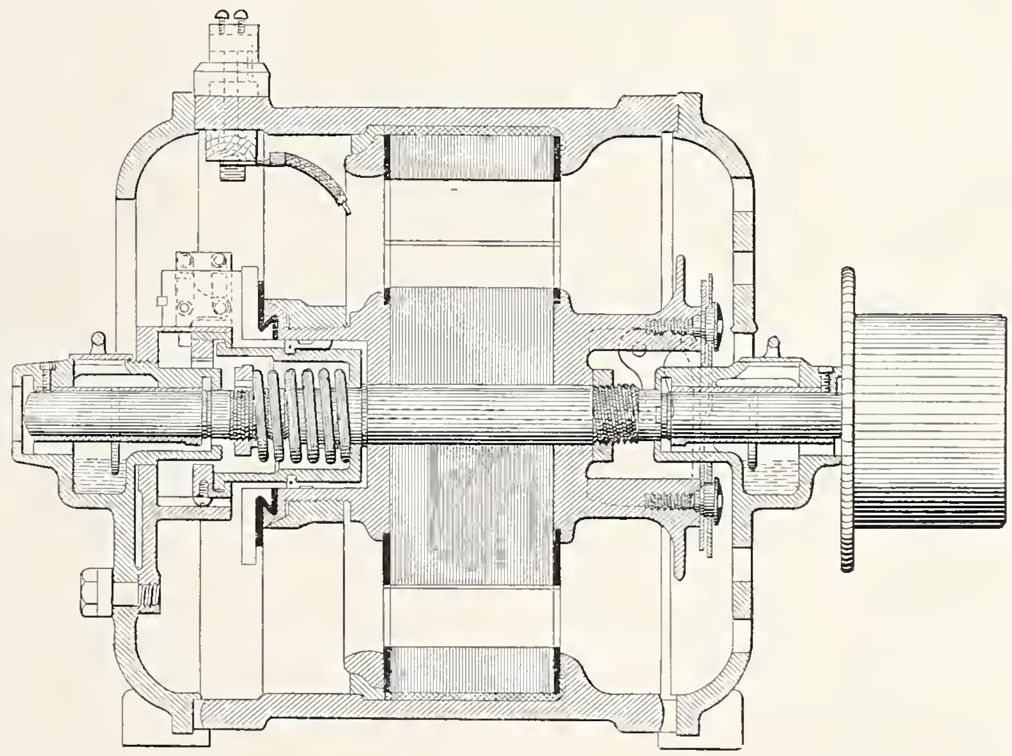
and in closing there is no danger of forcing them to their seats so tightly but that they can be easily opened without the intervention of hand power. They are made in all sizes and lists from 6 inches to 72 inches, and for both direct and alternating current of any voltage, phase or frequency.

The illustration on page 112 shows a 24-inch Chapman valve with special remote control and General Electric Company's motor. With this device the control may be located as remote as desired and indicates the exact position of the gate at all times. The valve may be opened or closed in any fractional part of the port by simply moving the controller handle to the desired point. When the gate has reached this position, the motor is automatically cut out. If emergency closing or opening is desired, it is only necessary to push any one of the numerous buttons located at different points. The valve will close and automatically cut off the current. This apparatus may be seen in operation at the General Electric Company's exhibit, Space 28, Palace of Electricity.

The single-phase motors of the Wagner Electric Company are filling a field which has been hitherto unoccupied, for they can be used in places either where a supply of single or polyphase current is available. The motor is applicable except where frequent starting and stopping, or where wide speed variation is desired. It is of the induction type, and can be operated upon a single-phase alternating-current circuit, or upon any one phase of a polyphase circuit. A single pair of wires furnishes power to this motor, and if the voltage is to be reduced, but one transformer is used. No starting box or any other auxiliary device is required. The attendant simply closes the main line switch, and the motor takes care of itself. This one feature alone is of great convenience, as the switch may be located at any desired point however distant from the motor and the same satisfactory starting results be secured. For hydraulic work the circuit may be opened and closed by an automatic float or pressure switch.

While running up to speed, the armature connections are such as to place the commutator in service, it being short-circuited through the brushes bearing upon it. On attaining full speed, the automatic governor comes into play, short-circuiting every commutator bar and simultaneously lifting off the carbon brushes. When it is very essential to hold down the starting current, an ordinary rheostat may be used to cut down the pressure at starting. It is possible for these motors to be wound to provide any degree of starting torque necessary. Where the conditions of starting are particularly severe, calling for as much as 50 per cent. to 75 per cent. in excess of full load torque, such torque can be provided by special winding without affecting the full-load running efficiency of the motor.





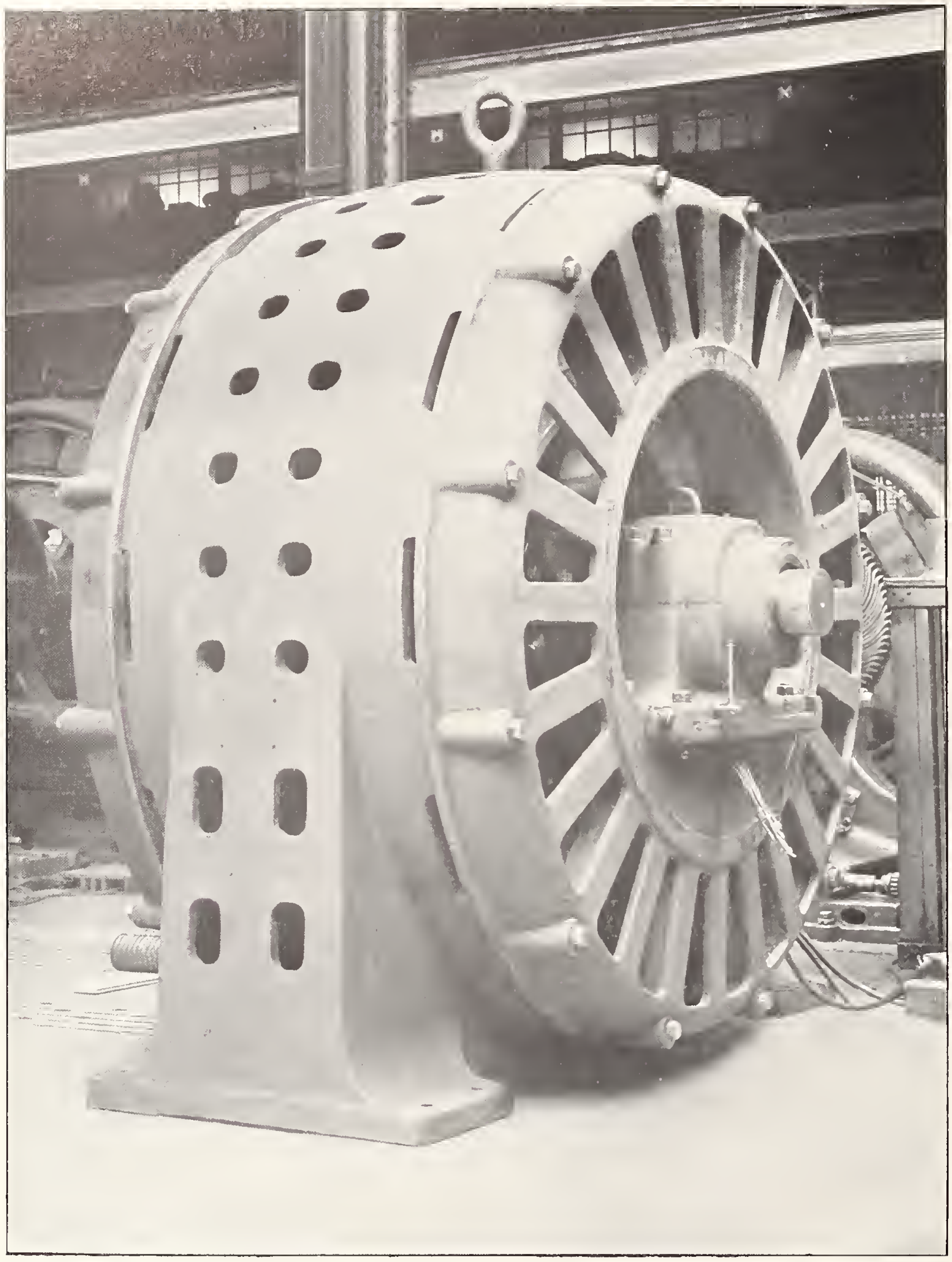
SECTIONAL VIEWS OF THE MOTOR MADE BY THE WAGNER MANUFACTURING COMPANY

The construction of the motor is shown diagrammatically by the two cross sections on this page.

The motors are being used very successfully for pumping work, linotype machines, constant-speed shop drive, blowers, church organs and like service. The illustration on page 114 shows the motor geared to a triplex pump with water tank and a float for automatically starting and stopping.

A pumping plant of large capacity had to be provided for the great cascades, which embody the most striking feature of the St. Louis Exposition. Few who look upon the flow of the cascades stop to consider that somewhere in the great hill on which Festival Hall is constructed must be hidden powerful pumps such as are found in but a few places in the world. The three 2000-H. P. induction motors which operate these pumps are the largest ever built.

When the cascades pumping plant was designed, it was estimated that it would have a capacity of 90,000 gallons a minute. As a matter of fact the actual flow of water has never been measured, and could be measured only by a rather expensive system of metering. All estimates which have gone forth since the opening of the



A 2000-H. P. WESTINGHOUSE INDUCTION MOTOR

Fair have been mere guesswork, and the one fact remains that the capacity of the plant is 90,000 gallons a minute, or 5,400,000 gallons an hour, said to be twice the total consumption of water by the city of St. Louis.

The induction motors are direct connected to Worthington centrifugal pumps and each unit may work independently. They are located under the east cascade, the entrance to them passing beside the steps, which are guarded against casual visitors. The motors are remarkable for their high efficiency and for the high voltage at which they operate. They are wound for three-phase, 6600 volts, 3000 alternations, corresponding to a synchronous speed of 375 revolutions per minute, the actual speed being about 365 revolutions. The primary winding consists of machine-wound, heavy insulated coils, put into half-closed slots of the laminations. The coils were especially treated before insertion with regard to the excessive high tension of the machinery. The secondary is also phase-wound, but for a lower voltage, the ends of the winding going to three collector rings, and from them to the starting rheostat.

Motors of such great capacity must be started with great care if the generating plant is not to be affected. In this case, the pumps are kept ready for work and filled with water, being connected to the city water mains in order that they might be filled at any time should they in some way be emptied. As the cascades run every day and in the evening at regular hours, the attendants at the Westinghouse exposition service plant in Machinery Hall know the time of starting the motors, the voltage is kept at about 4500, and after the motors have been started the voltage on the generators is gradually raised to 6600. The starting rheostat consists of many grid-type resistances placed on shelves where they are well ventilated. They are put into circuit by means of large, oil-immersed controllers operated by hand. These controllers, because of the exceptionally large size of the motors, have an unusually large number of steps. The starting has been done since the opening of the Exposition without accident, and is performed very smoothly, the starting current being raised up gradually from about one-half of the normal current.

The switch-board is provided with high-tension, oil-immersed, automatic circuit-breakers, and with Westinghouse ammeters and voltmeters for each space. Integrating and indicating wattmeters are provided at the outgoing ends of the cables at the main switchboard of the generating plant in Machinery Hall. The motors operate under exceptionally heavy conditions in a very humid place with a floor at the level of the lagoons. To protect the motors against moisture, it has been considered necessary to circulate direct current of considerable strength through the windings for a part of the time during which they are out of service.

Automobiles Versus Horses for Police Work

FIGURES recently compiled by the authorities of Hartford, Conn., which was the first American city to abolish the horse and substitute automobiles for police-department work, indicate that the cost of maintenance for an electric outfit in the department is about 60 per cent. of that when horses were used.

The automobile equipment installed three years ago comprises an electric patrol wagon and an electric ambulance, the two doing the work of four horse-drawn vehicles. In his report, Cornelius J. Ryan, chief of police, states that the patrol service covers the entire city, which has 90,000 inhabitants, spread over an area of 10 square miles. The report is a strong indorsement of electric vehicles, especially for city use.

The recently issued quarterly fire report of the electrical bureau of the National Board of Fire Underwriters again proves that many fires attributed to electric origin are, on careful inspection, found to be, in many cases, due to other causes. Reports of 145 actual electrical fires, aggregating a loss of $172,000, were received during the quarter ended with June.

Finances of Electric Railways

By WM. D. MARKS, Consulting Engineer

IN this discussion of the finances of electric railways it is necessary to begin by limiting the field in such a manner as will permit the consideration of only as yet inconsidered matters relating to the construction and operation of electric railways.

The standard method of keeping electric railway accounts leaves little or nothing to be desired in the recording of their operation. The placing of the securities of electric roads has become the special business of a large number of banking houses and brokers.

Whenever it has heretofore been thought profitable to build an electric railway, the basis for confidence in the project has been the judgment, in the form of generalization of the opinion of its promoters. This opinion is generally followed by a survey and estimate of the cost of construction by some engineer. If the engineer has added to his last estimate an opinion as to the gross earnings of the road, he has, with the hesitation due to his scientific training and its resulting honesty of thought, rarely asked his readers to give to it the confidence which he justly claims for his engineering figures.

Thus launched, the railway is left to work out for itself the answer to the fundamental question in all commercial enterprises—will it pay? To answer this question is the task which the writer has set for himself.

Answering this question in advance of the construction of an electric railway has been almost a labor of Hercules, requiring drudgery in statistical computations, and often resulting in the finding of fundamental data wrong and the work consequently worthless, or where the correctness of the data was assured reaching puzzling and apparently contradictory results. Only apparently, however, for as years have passed, the writer has learned that many puzzling results have only to be considered in the light of broader knowledge of the field to prove themselves a well-fitting part of a harmonious whole.

Before taking up the consideration of the details of electric railway earnings and finances, it will clear up the situation to arrange the 799 operating railways of 1902 in classes according to the population served, and to say that the gross earnings of a road should be about 20 per cent. of the cash cost of its construction and equipment ready to operate in order to render it a safe investment.

Since experience has shown us that the average operating expenses stated in percentages of gross earnings range between $53\frac{1}{2}$ per cent. in cities, and 68 per cent. in small towns, it is obvious, under the assumption that the investment is five times the annual gross earnings, that the net profit on the warranted investment will range between 9.3 per cent. and 6.4 per cent. To avoid ambiguity the reader will understand that no reference whatever is intended in the following to the various and widely differing capitalizations of electric railways.

TABLE I.—Averages of 799 Street Railways, 1902.

Classification Population Served.	Number of Companies.	Operating Expenses Per Cent. Earnings.	Earnings per Mile of Single Track Operated.	Earnings per Car Mile.	Earnings per Passenger.	Operating Expenses per Car Mile. Total.	For Power.	For Cars.	Net Earnings Per Cent. of Total Capitalization.
Urban and Suburban.		%	$	Cents.	Cents.	Cents.	Cents.	Cents.	%
Over 500,000	65	55	24 360	23. 9	4.75	13 2	1.9	6.1	5.15
100,000 to 500,000	47	53.54	14,329	21.19	4.93	11.34	1.6	5 4	5.94
25,000 to 100,000	83	59.31	5,922	20.36	4.78	12.07	1.9	4 9	5.14
Under 25,000	312	68.09	5,440	18.91	4.83	12.87	3 2	4 4	4.5
Interurban.									
High speed—great length	54	58 03	4,339	21.25	6.76	12.33	2.4	4.7	3.32
Miscellaneous	238	66.36	4,982	20.93	5.09	13.89	2.9	5.3	3 80
Total	799	------	------	------	------	-----	----	----	------

From Table I we have the following average results as to a safe investment in electric railways:—

For cities of over 500,000 population, a safe investment is $120,000 per mile; for cities of over 100,000 population, it will be $70,000 per mile; for cities of over 30,000 population it will be $25,000 per mile; for towns of under 25,000 population, it will be $25,000 per mile, and for interurban railways it will be $22,500 per mile.

However interesting these average results may be, they are valueless to the investor in any particular railway which may differ widely from the average of its own class. Generally we may say it is never safe to rely on averages in predicting the future earnings of any particular railway.

Obviously, however, in cities of over 100,000 population, the gross earnings per mile of single track warrant an investment so much in excess of the highest cost of a fully-equipped and well-constructed railway as to leave them entirely out of the doubtful class, save in very rare instances. In fact, the percentage of net profit on the actual cash cost of these railways is far in excess of the 9.3 per cent. previously stated, and we can dismiss them from further consideration as safe investments.

Before discussing the four remaining classes in Table I, it will be of service to examine the characteristics of the growth of cities and their influence on the patronage of electric railways.

In a brochure, "The Finances of Gas and Electricity Manufacturing Enterprises," page 91, the writer has shown, with sufficient accuracy for commercial purposes, that in cities of less than 75,000 population the sale of gas per capita is a function of the price per 1000 cubic feet, and is connected with it by the equation of an equilateral hyperbola. This rude relation, however, ceases when cities surpass 75,000 population, and the sale of gas not only continues to increase with the population, but also increases in amount per capita, the price of gas usually being about $1 per 1000 feet.

This law also appears to apply to electric lighting sales per capita, although so few companies for electric lighting have an intelligently worked-out scale of prices for lighting that it cannot be shown with the distinctness that obtains in the older industry

of gas making. Those familiar with the finances of trolley railways only need to be reminded to recall many instances of the change for the better in railway earnings, realized at the time when a given city surpassed 75,000 population.

At this point tall office buildings, great retail shops, factories of all sorts and many theatres and churches come into existence. Life becomes more strenuous and the style of living more luxurious. All classes that use gas, electricity and trolley roads increase in numbers and in activity. The wealthy remove to suburban homes and the working classes rely on amusement parks in the suburbs for relief from summer's heat. The town has burst its chrysalis and emerged as a metropolis. It becomes a mother city to all surrounding villages and daily draws their inhabitants to it for work and for pleasure. In manufacturing cities this change begins before the population reaches 75,000, and in agricultural centers it is perhaps somewhat deferred, but at about this point the change occurs.

Electric railways located in cities of over 25,000 population depend for their future, if they have as yet remained below 75,000, upon the rapidity of growth of the city selected. Franchises can be more easily procured in such cities, and with a rapid growth the promoter secures a prize at a relatively small cost.

It is very unusual to find a largely profitable trolley road in a city of less than 50,000 population, particularly if it has no suburban or interurban branches. The distances are short, and as business, except in a manufacturing town, is usually conducted in a leisurely fashion, the inhabitants prefer to walk.

There are, of course, special conditions—such as the presence of factories, schools or mines—having a large portion of the population attached to them, which make a difference in favor of a trolley road, but these are exceptional factors and cannot be included in a generalization.

If the truth were known very few roads confined to the limits of a community of 25,000 souls would be found paying operating expenses and a fair rate of interest on the actual investment required to build the cheapest form of electric road. This statement is made more particularly of those roads that have not offered inducements to travel in the form of pleasure parks and interurban connections.

Charging repairs to investment and other expedients for apparently reducing the operating expenses do not alter the laws of nature or leave money for dividends and interest.

To make an electric railway pay in a small community requires the largest ability and thrift in operation, after the most careful and exhaustive study of the needs and characteristics of the community in fixing the road's location.

There are such roads that do pay, but it is a pity that the modest and able managers of them should not have a wider field in the management of the many outrageously mismanaged but paying roads of some of our larger cities, whose success is wholly due to their location in the midst of teeming multitudes.

Hitherto we have considered only urban railways in closely settled communities and their earning power per mile of single track. Comparison between these roads is a very simple matter, requiring only a consideration of the population and the characteristics of the city.

The interurban electric railway is a different matter. Instead of plodding along streets at a speed regulated by city ordinances, it has boldly challenged the steam locomotive express trains and found no difficulty in exceeding their speeds. Its roadbed no longer consists of the predetermined street grades, but is as carefully surveyed on private rights of way, and constructed with as easy grades and curves as the best of the great steam railway lines.

True, it is but recently that this has been done, for our first interurban roads were built with many misgivings as to profits, and so they stuck to turnpikes and country roads, avoiding the expense of a private right of way. But that is now past. The test has proved that good locations for electric interurban railways assure a profitable business and that these roads will carry many times more passengers than a steam road between the same points, obtain greater gross passenger earnings per mile of roadbed and, moreover, are able to do it for one-half to two-thirds the fare per passenger-mile of steam roads.

The reasons that this has come to pass are obvious now that experiment has brought them out. The cars run frequently (rarely less than one hour apart), they stop anywhere, or if not at stations only, short distances apart, and they are usually in operation from 6 a. m. till midnight. There is no station reeking with filth and foul air to wait in, no ticket seller to make children and timid women jump as he slaps down change and tickets, no crowded door or gateway to be jammed in as with a mad rush the crowd scrambles for seats, and no belated train, for there is no time table to be consulted, only the recollection of the car interval being necessary. The conductor of an electric car is the ticket seller and the whole depot and train crew, save the motorman. You can start when you please and return when you feel like it.

Perhaps a story of Indianapolis will best illustrate this. This city has had an exceptionally large steam railway surburban service for many years. Within the last two years nearly every steam road into Indianapolis has been paralleled by an electric interurban railway. With their completion, a merchant in a large establishment noticed a great increase of ladies who carried away their own packages, and being eager to learn he made a number of inquiries of the new comers as to why they had never patronized him before or come to the city. To more than one-half these inquiries the reply was, "Because I couldn't go home when I pleased." They had come on the electric cars and were deposited in front of his store, besides being carried back in the same manner.

Referring back to Table I we see that the average safe investment per mile of roadbed in an interurban single track road is about $22,500 for an average gross earning of $4500. For the sake of emphasis the writer repeats that averages are of no value when taken from 292 roads in all parts of the United States for the purpose of forecasting the gross earnings of a single road.

The figures used with a single road should be selected from roads similar as to population and distribution of it, of similar length and operated generally in a country and under conditions akin to the proposed road. While general averages do not apply to gross annual earnings of a mile of roadbed, they do apply with great impressiveness to the earnings of the car mile and the operating expenses per car mile.

When first deduced it hardly seemed possible that the car mile earnings—23.69 cents—in a great metropolis should exceed those of a high-speed interurban car mile—21.25 cents—by only 2.44 cents, and that this result should be corroborated to within a few cents by the car mile earnings of all classes of electric railways, but such is the indisputable fact. Possibly the explanation of this close average is that the operating expenses per car mile are remarkably uniform in all classes (see Table I), and that railway managers desire to furnish as frequent a service as is possible with profit to the company.

Referring to Tables II and III, the average uniformity of the operating expenses is calculated to mislead as to their varying values in interurban

roads. Table I gives them as about 13 cents for 799 railways; Table II as about 13.1 cents for fifteen railways, and Table III as about 12.7 for 3 railways. Yet in these latter tables individual instance range from 9.05 cents to 16.53 cents. Even higher operative costs are frequently obtained, with perfectly good excuses, by the management of interurban roads not cited in this discussion.

There is a limit to the gross earnings of a road below which they are not worth discussing. From previous extreme schedule of one car per hour is adopted. Experiments with less frequent car service confuse the public and discourage passengers, only making matters worse.

Referring to Table II, we observe that but eight out of fifteen interurban roads, and in Table III but ten out of fifteen interurban roads were profitable ventures in 1902 and 1903.

It appears to be customary in the endeavor to place the securities of electric railways to lay all stress upon the operating expenses in terms of the a high rate of fare per passenger mile. In short, after a road has reached an earning capacity of $3000 per mile, the per cent. of operating expenses reduce themselves, if permitted to do so, the percentage becoming smaller as the gross earnings per mile becomes larger.

Obviously, a railway beginning in, ending in and passing through a very thinly settled country will not prove profitable, because of the lack of possible travelers, however great the desire of the population to travel may

TABLE II.—INTERURBAN ELECTRIC RAILWAYS, 1902.

MASSACHUSETTS, 1900.
Lawrence, Population 62,559
Worcester, " 118,421
Taunton, " 31,036
Springfield, " 62,059

Name of Roads	Miles Road Bed.	Per Mile of Road Bed. Gross Passenger Earnings.	Per Cent.	Stated Construction and Equipment.	Population Towns, 1900.	Passenger Fares, 1902.	Car Miles.	Speed per Hour, Average Miles.	Per Car Mile. Gross Earnings, Cents.	Total Operating Expenses, Cents.	Operating Expenses, Per Cent. Gross Earnings.	Gross Earnings Per Capita. Population of all Towns Included.	Metropolis Omitted.	Net Profit in Per Cent Capitalization	Fare Per Passenger, Mile. Cents.
Haverhill & Amesbury	26.61	$4,193	13.3	$31,564	2,480	87,495	19,200	8.2	21.89	14.08	64	$1.69	----	4.8	1.21
Brockton & Plymouth	22.09	4,058	12.	33.843	905	81,471	20,000	?	20.80	13.35	64	----	$4.48	4.3	?
Worcester & Webster	14.91	4,020	12.3	32,726	871	66 324	20,904	8.7	19.25	16.53	86	----	4 62	1.7	?
Southbridge & Sturbridge	7.60	4,003	20.2	19,800	1,600	81,499	19,475	8.	20 55	16.52	80	2 50	----	4.0	1.25
Concord, M. & Hudson	12.47	3,727	12.2	30,571	1,386	74,369	21,220	11.3	17.56	13.25	75	2.33	----	3.1	1.38
Lawrence & Reading	11.50	3,576	10.3	34,758	1,115	72,545	23,097	14 4	15.48	15.21	98	----	3.21	Omit	?
Springfield & Eastern	28.37	3,324	11.8	28,188	867	66,973	19 835	10.2	16.75	11.33	68	----	3.83	3.8	?
Bristol County	15.99	3,099	9.2	33,717	1,162	61,974	24,229	?	12.79	9.83	77	----	2.67	2.1	0.87
Milford, A. & Woonsocket	30.	2,475	12.1	20,446	1,924	49,498	18,427	20.6	13.43	9.42	70	1.28	----	3.6	?
Marlboro & Westboro	13.51	2,242	8.1	27 924	1,768	49 786	12,400	?	18.08	15.88	82	1.27	----	1.5	?
Georgetown, R. & Ipswich	17.92	2,237	9.5	23,625	1,341	48,140	14.944	?	14.97	9.05	60	1.67	----	3.8	?
Blue Hill Street Railway	10.67	2,200	8.9	24,636	1,646	46,236	14,512	8 6	15.84	16.31	103	1.34	----	Loss	?
Hampshire & Worcester	11.71	1,840	7.1	26,045	881	36,858	11,740	?	15.68	10.54	67	2.09	----	2 3	1.
Milford & Uxbridge	33.69	----	----	26,190	1,201	32,589	21.168	?	24.23	14.26	59		----	----	----
Norton & Taunton	29.	1,578	7.6	20,770	759	32,416	12,086	?	13 05	10.61	81	----	2.08	1.4	?

figures we have seen that an average limit of investment in interurban electric railways is $22,500 per mile; interest on investment, $22,500 at 6 per cent., $1350; 13,140 car miles at 13 cents, $1708; total, $3058.

These 13,140 car miles annually correspond to an hourly schedule each gross earning percentage. We have just proved that a road earning less than $3000 gross per mile is not worth building, yet reference to Tables II and III will show a number of these unprofitable roads which report operating expenses as low as 57, 59 and 60 per cent. of their gross earnings.

be. On the other hand, a railway running through a densely peopled country will be unprofitable unless the people have a desire to travel on it.

From the United States census of 1900 it is possible to obtain the populations of the minor civil divisions through which an electric railway

TABLE III.—OHIO INTERURBAN ELECTRIC RAILWAYS, 1903.

Lorain, Population (1900).. 16,028
Cincinnati, " " .. 352 902
Dayton, " " .. 85,333
Columbus, " " .. 125.560
Toledo, " " .. 131 822

Names of Railways.	Miles Road Bed.	Per Mile of Road Bed. Gross Passenger Earnings.	Per Cent.	Stated Construction and Equipment.	Population Towns, 1900.	Passenger Fares, 1900.	Car Miles.	Speed per Hour, Average Miles.	Per Car Mile. Gross Earnings. Cents.	Total Operating Expenses, Cents	Operating Expenses, Per Cent. Gross Earnings.	Gross Earnings Per Capita. Population of all Towns Included.	Metropolis Omitted.	Net Profit in Per Cent. Capitalization.	Fare Per Pass., Mile. Cents.
Lorain Street Railway (1902)	9.60	$8,517	6 3	$135,417	2,808	224 200	43,887	15 5	19.40	----	--	----	$3,03	--	1.
Cincinnati, Dayton & Toledo (1903)	69.67	6,982	7.5	93,300	1,268	67,017	31,433	12.	22.21	12.41	55.9	----	5.5!	4.1	--
Tol., Bowl'g Gr. & Southern (1903)	40.	6,173	14.5	42,410	1,044	47,404	13,733	--	18.	9.60	53.1	----	5 90	6.7	2.
Columbus, B. L. & Newark (1903)	39.5	4,764	7.2	66,460	771	----	----	--	----	----	--	----	6.18	--	1.5
Dayton, Springfield & Urbana (1903)	45.53	4.298	13.	33,160	1,331	7,983	3,990	--	?	----	--	----	3.23	--	--
Toledo & Maumee Valley (1902)	19.52	3,862	9.4	40,990	590	37,477	20,331	10.6	----	----	--	----	6.09	--	--
Toledo, Fostoria & Findlay (1903)	16.	3,826	6.8	56,250	1,829	26,299	17,376	19.5	22.20	----	--	$2.09	----	--	1.5
Springfield & Xenia (5 months)	18.	*3,679	5.6	55,550	1,206	----	---	18.		----	--	----	3.05	--	1.5
Dayton & Troy (1903)	33.	3,569	10.	35,710	812	22,121	21,457	16.2	16.60	----	--	----	4.39	--	--
Tiffin, Fostoria & Eastern	16.5	*3,100	14.6	21,210	1,300	19,863	17,443	18.8	17.70	----	*67.	----	2.39	4.9	2.1
Lake Shore (1902)	155.	2,938	4.7	62,330	483	23,800	14,936	14.2	19.69	----	67.2	----	6 09	1.5	--
Pennsylvania & Ohio (1903)	27.	2.706	5.3	50,370	1,029	28,087	10,653	--	25.40	----	--	2.63	----	--	--
Dayton & Northern (1903)	39.	2.485	11.4	22,500	572	14,895	12,567	18.7	19 77	----	--	----	4.35	1.5	--
Eastern Ohio (1903)	85.	2,262	4.3	*52,000	237	8,404	8,115	--	27.88	16.02	57 1	----	9.55	1.8	2.
Dayton & Xenia (1903)	49.06	2,016	6.2	32,600	340	19,308	9,912	15.9	20.34	----	--	----	5 93	--	--

NOTE.—* Estimated. Gross earnings of above roads increased 36 per cent. from 1902 to 1903.

way, eighteen hours each of the 365 days in the year, for each mile of roadbed. It will be obvious that a road whose gross earnings per mile of roadbed do not exceed $3000 annually is not a profitable venture, even if the

An unusual instance may be found in the Tiffin, Fostoria & Eastern Electric Railway in Ohio, which has paid 5 per cent on its capitalization of $21,000 per mile, but this road has an unusually good management and charges passes. We can find the population per mile length of roadbed in these minor civil divisions, but without a careful personal inspection of the line we cannot learn the distribution of this population along the line within short

and accessible distances from it, nor can we learn where this population is likely to gather for business or pleasure.

The amount of travel on the line of any road is largely influenced by the manner of distribution of the population along it, as well as by the avocations of the people. It has been observed that a manufacturing community yields the largest gross earnings per capita of population for a given fare per passenger mile. A residential and commercial community is second in value, while an agricultural community yields a relatively small amount per capita.

There are unusual conditions with a few electric railways such as those in a mining community, or those of hauling freight, which do not permit them to be classified, they requiring independent researches into their peculiarities. It is proper to omit the population of large cities served by separate electric railway systems from the computations made for interurban lines for reasons which will be explained later.

While it is necessary to use the populations of the minor civil divisions in the computations for a given road, it is very doubtful indeed if the influence of any electric road can be felt seriously at a distance of 3 miles each way from it. Indeed, it would appear when walking is the means of reaching a road in all weathers, as if 1 mile could be placed as the distance within which its patrons can be found.

The greater portion of travelers on an interurban invariably come from the closely settled villages and towns which it serves. The residents of the larger cities rarely use an interurban road, save for pleasure travel in the summer, and then usually to visit some park or summer theatre. The pleasure roads around Washington D. C., furnish an interesting study of this phase of travel.

Should one, in the endeavor to forecast the earnings of a projected road, depend only on the population per mile of road, he would lead himself into very grave errors—the inducements to travel count for more than the amount of population. Thus, in Table II we find the Worcester & Webster Electric Railway, with an interurban population of 872 per mile, earning $4020, while the Georgetown, Rowley & Ipswich Electric Railway, with an interurban population of 1341, earns but $2237 per mile of roadbed.

In Table III we find the Columbus, Buckeye Lake & Newark Electric Railway earning $4764, with a population of 771 per mile, and the Pennsylvania & Ohio, earning $2706, with an interurban population of 1029 per mile. The explanation is that the presence of a metropolis on the line of any interurban road is the greatest possible inducement to travel. Thus we find Worcester making the value of each inhabitant $4.62 to the Worcester & Webster Electric Railway, and Columbus making the per capita value of the interurban population $6.18 to the Columbus, Buckeye Lake & Newark Railway. In the cases of the Georgetown, Rowley & Ipswich Electric Railway and the Pennsylvania & Ohio the gross earnings per capita of interurban population is $1.67 for the former and $2.63 for the latter. There are many minor inducements to travel which add to the gross earnings per capita of a road. Clean and elegantly designed cars are more attractive to the public, as the latter take no interest in the other details of the road's construction. A little extravagance in cars, however great the economies in other directions, is always a paying investment.

The astonishingly large number of passengers carried, as compared with steam roads, can be said to be due entirely to the frequency and regularity of the electric car service between 6 a. m. and midnight. Connections with other roads, whether by intersecting them or by extending a road, always increase the passenger traffic.

Recreation parks are an almost universal inducement offered by electric railways to obtain summer travel. They require of the road a large summer equipment that is idle during the winter, and in many instances, particularly when the park is off the main line and has to have a special track built to it, they have proved a loss in the long run. When very large cities are near these parks they have sometimes proved very profitable, not only to the road but in themselves as well.

An electric road paralleling a steam road without attempting to rival it in speed generally pays well, as it gets all the short trip traffic and assists itself and the steam railway also by bringing passengers to the steam road depots. Reduction of fares below steam road standard prices has proved a great inducement to travel to people who are not obliged by business to save time in transit. Nearly every steam road in the United States carries its passengers without profit.

Some of the worst managed roads in the United States are the most profitable, and some of the best managed roads are hopelessly unprofitable. In both these cases the cause of their success or failure is their location. The best of management cannot make the operation of a road profitable in a bad locality, but it can make a good location more profitable. A good location is a "sine qua non" for all roads from which profit is expected. A bad location is like a stratagem in war, wherein a man can err but once.

The ordinary electric trolley road is a competitor of horses and carriages; it is the poor people's carriage, and it should go where they are, and, seek-seeking them out, persuade them to ride by its presence. An interurban trolley should always go to the heart of a metropolis in the most direct way possible, and it should pass through the center of population of each small town and village that it enters. It should avoid transfers to other cars, for people unconsciously resent small annoyances more than serious injuries.

The exceedingly grave responsibility of deciding as to the advisability of the investment of sums ranging from hundreds of thousands to millions of dollars in electric railways makes the writer regard it as a task for which no labor is too severe, no precautions too elaborate to guard against the possibility of error. Until this matter of the profitableness of a road is decided, all others should wait, and no expenditures should be made, save perhaps a rapid survey and profile of the proposed line. No institution can be of any permanent value to any community if, in the prosecution of its work, it does not realize a profit.

Failure due to lack of judgment in the location an electric railway is far reaching in its effects—it not only causes unfortunate investors in it to lose their money, but it also makes the public lose confidence, and they fail to support well-studied and profitable railway enterprises which would greatly increase the prosperity of the general community.

In a lecture before the Franklin Institute in September, 1890, the writer predicted that an electric railway would be operated in the future at a maximum speed of 150 miles an hour. The track required was described and the power of the stations and generators required was indicated. During the year 1903 the Marienfeld-Zossen Electric Railway reached a speed of 140 miles an hour on a track which conformed to the writer's predictions.

To no such road as this do the meagre data to which limited space confines us apply, but for the ordinary electric roads, such as are at our daily convenience, it will serve our purpose in deciding whether or no their futures will be profitable. In such cases as these the method of procedure should be as follows for interurban electric railways:—

A reconnoisance of the line of the

road with special care in looking for difficulties of construction.

A careful study of the metropolis and other subsidiary towns and villages to which is added a study of the resources and characteristics of the field occupied.

A deduction of the gross passenger earnings from precedents derived from similar roads and their per capita earnings.

A deduction of the gross freight and express earnings from investigation in detail of the field.

The deduction from the above of the possible gross earnings and from these the safe investment allowable.

An estimate of the actual cash cost of the construction and equipment of the road ready for operation.

These figures can be checked by means of estimated passenger fares from similar roads multiplied by the ratio of passengers to population and the population per mile, and by multiplying the average car miles per mile of roadbed by the gross earnings per car mile of similar roads.

Lightning, Its Causes and Effects

By H. W. SPANG

A THUNDERSTORM invariably takes place between those portions of the atmosphere in strong thermal contrast by the descending cold air flowing over the surface of the earth, and lifting the warm air, thus producing irregular masses of clouds. The great violence with which the warm air rushes over the cold air, so different in temperature and density, produces a great condensation of vapor and generation of electricity, so characteristic of such a storm.

It is supposed that either the motion of the wind, causing friction between the air particles, or the water-vapor rapidly condensing into a liquid, is in some way the cause of the greatly increased electrification of the air. A snow-storm accompanied with a high wind and a volcanic eruption are likewise attended with a great generation of electricity in the air accompanied by lightning.

Highly electrified clouds, which are invariably positively electrified, cause the adjacent air, the earth and everything thereon, to become intensely negatively electrified by induction. The area of earth thus electrified is about equal to the area of the overhead electrified cloud formation, and, judging from the destructive effects in deep underground mines, and the killing of fish by lightning discharges in line with ponds and rivers, such electrification extends deep into the subterranean water-bed and bodies of water, and not upon the surface of the earth and water, as is generally supposed.

The sandy soil and low depth of water-bed of Brooklyn and Long Island are more conducive to lightning discharges than the rock formation underlying a large portion of the borough of Manhattan.

When the attraction between the positive electricity of a storm-cloud and the negative electricity of the earth is able to overcome the resistance offered by the intervening air, simultaneous electrical movements take place within the electrified cloud and earth areas, which are attended with a series of flashes in quick succession, giving rise to the vivid, quivering light, known as lightning.

Before any movement is made by these opposite electricities, every line or path which they will take has been selected by induction, and every action and effect can be explained. There are no freaks in the lightning discharge.

The height of thunder-clouds above the earth varies from about 500 to 25,000 feet, the average being about 2500 feet.

In Fig. 2 is shown a concentrated discharge from a central low point of cloud, with the electricity of the cloud flowing toward the central point. In Fig. 1 the electricity from the clouds spreads out as it approaches the hay in the loft of a barn, and in Fig. 3 it is greatly retarded by a rock formation, and is compelled to pursue a long, irregular path.

In Fig. 4 there is great diffusion from a low cloud during heavy rainfall, giving rise to the sheet lightning effect. The greater the diffusion of the electricity in its flow from the clouds to the earth, the less dangerous and destructive it is.

It was customary years ago to ring the church bells with a view of preventing the formation of thunder-clouds and lightning discharges. A German scientist, in 1783, computed that in the course of thirty-three years lightning had struck 386 church steeples on the Continent, killing 121 bell-ringers and injuring many more.

In 1750 and 1763, the Dutch Church in New York City was struck by lightning and greatly damaged. It was equipped with a Franklin lightning rod in 1764, which prevented damage when a lightning discharge occurred in 1765 in line therewith.

Up to the time of the introduction of water and gas pipes into churches and other buildings, the Franklin rod was a fair success as a lightning conductor, this being accounted for by the fact that the electricity from the

FIG. 1.—THIS FLASH OF LIGHTNING FIRED A BARN AND KILLED A TRAMP

clouds, while flowing to the earth, divided into numerous branches, of which the rod received one branch, and adjacent houses, trees or other objects the other branches.

Since the introduction of underground water and gas pipes, railway tracks and the like, the electricity from the clouds is usually concentrated while flowing toward the earth and such extended metal conductors.

It has been fully demonstrated that owing to the great height of thunderclouds, pointed lightning rods cannot perform the function of silently tapping the electricity contained in an overhead cloud, and of preventing a lightning discharge in line with the building to which the rod is attached. With low clouds the Eiffel Tower, 985 feet in height, prevents lightning discharges in its immediate vicinity, but it has been struck on a number of occasions by discharges from high clouds.

The overhead telegraph, telephone, electric light and other electrical wires do not relieve the electric tension or prevent lightning discharges, as is generally supposed. On the contrary, they invite lightning discharges, and, under the present unscientific lightning protection practice, they contribute to the increasing loss by lightning.

The number of buildings ignited or otherwise damaged by lightning in this country has increased from 625, with a loss of $1,618,539 in 1890, to 3440, with a loss of $5,272,835 in 1900, most of which was in the suburban districts.

FIG. 2.—A CONCENTRATED DISCHARGE FROM A CENTRAL POINT IN THE CLOUD

Nature has provided lightning discharges for our welfare, and they ought not to be prevented. They generate ozone, which neutralizes the effect of the miasma of the air, and they thereby prevent epidemics. They also combine gases held in suspension, producing chemical agents, which are essential for the growth of vegetation and plants.

Since the days of Franklin, scientists and electricians have neglected to investigate the electrical actions and effects of nature, which accounts for the general failure to determine the proper requirements for lightning protection for buildings, electrical circuits, and the like. They have erroneously been governed by Leyden-jar and other insufficient laboratory experiments, which are not illustrative of a lightning discharge.

It is evident that the extent of the terrestrial electrical charge participating in a lightning discharge is generally unknown, when we consider the universal lightning protection rule of terminating a lightning conductor in a well, or with an ordinary metal plate embedded in moist earth or charcoal.

For ages Nature has been clearly indicating that the electricity of the clouds can unite with that of the earth only within a wide area, and not at a single point or within a small area, as is generally supposed. Reference was made by Greek writers over 2200 years ago to the great attraction of lightning discharges for great oak and other trees with outstretching branches and dense foliage. Similar phenomena were observed by Franklin, Faraday, Henry and other eminent scientists of the last century, and these phenomena were not fully understood by them.

The opposite electricities of the clouds and earth, while uniting during a lightning discharge, select a great tree, hay-stack, a well-filled barn, granary, ice-house or storage house, lumber yard or a great assemblage of persons, whether in a circus, grand stand of a race-track, or church, a herd of cattle or a flock of sheep, for the reason that any of the foregoing or other greatly and compactly stored material offers a medium of wide scope, by which these electricities can unite.

The stone, brick, wood, slate and other non-metallic material of a church or other great building become electrified by induction during a thunder-storm. For these the opposite electricities have a greater attraction than for the ordinary Frankline rod, owing to the greater scope offered by the building itself.

The immunity of buildings in cities from great damage by lightning is principally due to the steam exhaust pipes which extend above the roofs and are connected with the plexus of street water-mains via the engines, boilers and service pipes in cellars, thereby fortuitously constituting an excellent medium of great scope for effecting the quick and safe union of the opposite electricities of the clouds and earth.

Nature has in numerous other ways

FIG. 3.—THE IRREGULAR PATH OF THE LIGHTNING WAS CAUSED BY A ROCK FORMATION

been clearly revealing the proper lightning protection requirements for buildings, electrical circuits and the like, and the failure of architects and electricians to prevent lightning discharges is solely due to their misinterpretation of the electrical actions and wants of Nature. From a lightning standpoint, much of our architecture and electrical engineering is unscientific and defective.

The varied metal work about a suburban residence, as ridges, valleys, gutters, leaders, heating, ventilating, water, drainage and other metal pipes are electrically insulated from each other by wood, plaster, brick or stone; but, nevertheless, they offer a wide scope and a hundred-fold greater attraction for the opposite electricities than that offered by an ordinary lightning rod terminating in the earth adjacent to the building.

The ignition or shattering of the intervening wood-work and other nonmetallic material invariably attends a lightning discharge in line with such a building. The steel frame-work and great iron caissons of the modern skyscraper are also electrified by induction during a thunder-storm; but when they are separated by cement, brick and stone they do not bear a proper electrical relation to each other, and fissures will be created in such intervening material by terrific lightning discharges in line with the building.

The electric light circuits in a skyscraper or other building are also highly electrified by induction; but owing to a lack of a proper electrical relation between these circuits and the metal work of the building, the insulation of the wires is impaired by the induced charges at one or more convenient discharging points.

This impairment of the insulation may not manifest itself until an accidental ground connection is made in the circuit, this being at once attended with the flow of the electric light current over the impaired insulation, accompanied by an electric arc and fire. Many of the mysterious electric fires in buildings are primarily due to the induced electrical charges and effects attending lightning discharges.

About 20 per cent. of the electric current fires in suburban properties are now caused by the improper employment, inside of these properties, of lightning arresters connected with out-door telephone wires. Whenever these wires are broken or blown down during a sleet or high wind storm, and contact is made with overhead trolley wires, the trolley current flows to the telephone via such arresters, accompanied by a great flame, notwithstanding the usual safety fuses employed with the telephone circuits.

With the proper utilization of the metal work of buildings, and a scientific installation of electrical circuits therein, damage by lightning and other powerful electrical energy would soon become a thing almost unknown.

The opposite electricities have a great attraction for, and are invariably concentrated upon a church with a high spire or tower, which is thereby destroyed. In Fuller's Church History of Great Britain, it is stated that "scarcely a great abbey in England exists, which, once, at least, was not burnt down with the lightning from Heaven."

During the eleven years from 1890 to 1900, 588 churches in this country were ignited and destroyed by lightning. During the same period a large number of stone and brick spires were shattered without being ignited. In this and other countries are churches which have been damaged or destroyed by lightning six times.

In five churches in Europe struck by lightning, fifty-five persons were killed and 225 injured. One of these discharges occurred on June 25, 1901, during a funeral at Pinero, in the province of Orense, Spain, at which twenty-five were killed and thirty-five injured. Many such church casualties have occurred in this and other countries, in which from one to six were killed and from five to thirty injured.

In the modern church architecture, where steel frame-work electrically insulated from the earth is employed, destruction and death can be expected around the base of the metal uprights. Even the buildings of colleges, in which architecture and electric engineering are taught, lack proper lightning protection, and are standing satires in this scientific age.

FIG. 4.—A GREAT DIFFUSION FROM A LOW CLOUD DURING HEAVY RAIN-FALL—COMMONLY KNOWN AS SHEET-LIGHTNING

Some Points in Electric Station Design and Operation

By HOWARD S. KNOWLTON

A VERY limited experience in modern engineering convinces one that present day applied science rests upon a financial basis. The engineer used to be defined as one who utilized the force of nature in the service of mankind, and as long as his machinery turned and his bridges carried their designated loads, it was assumed that little else was left for him to do. The requirements of modern practice have compelled an extension of this definition, for the engineer of to-day is quite as much concerned with problems of dollars and cents as he is occupied with questions of the strength of materials and the laws of steam and electricity.

Someone has well said that the engineer can do with one dollar what anyone else could do with two, and no one who is familiar with the great industrial undertakings of our time can doubt that this characterization comes pretty near the truth. Certainly the world is growing more and more to realize that "a penny saved is a penny earned" in every department of business life. We realize that these are the days of small things as well as great ones when we see that a reduction of one mill per ton-mile in the cost of handling freight on our American railroads would in one year increase the net earnings by $150,000,000—a sum nearly equal to the total fire losses of 1903 in the United States and Canada.

If the cost of carrying passengers last year on the system of the Boston Elevated Railway Company could have been reduced by one-tenth of a cent per capita—nearly 2 per cent. of the average fare—the dividends on the capital stock could have been increased by almost a quarter of a million dollars. A reduction of 1 per cent. in operating expenses is just as effective as a like increase in gross earnings in its influence on profits.

Every form of business depending upon the sale of electricity or upon its application as the great moving spirit of an industry, offers a particularly attractive field for the institution of those economies in design and operation which, in the aggregate, save very considerable losses each year. It is a fortunate circumstance that the electrical units themselves are quantities small enough to be easily conceived. The size of these units and the practice of reducing investment and operating expenses to a unit basis allow a most convenient analysis of even the complicated business of central station lighting and power supply, or the intricacies of manufacturing costs in motor-driven factories. One of the ablest engineers now in active practice reduces every calculation which he makes to the kilowatt basis, greatly simplifying the problems which come to him, and enabling him to decide upon the economy of construction and operating propositions without regard to the total amounts of money involved.

Upon the design of every electrical installation depends, to a large degree, its operating economy. A wise choice of apparatus and a careful arrangement of it in the constructed plant are two long steps taken toward the earning of dividends. Unless the same standard of equipment is employed throughout every new system, the door is opened for inefficiency and waste to enter. Thus, in a street railway repair shop, pneumatic hoists are of little advantage if the speed of the work is dragged down at other points by the use of inferior tool steels or the equipment of the shop with a slow-moving, hand-operated travelling crane. Money spent to secure close engine regulation in an isolated plant is largely thrown away if the owners attempt to operate electric lights and elevators from the same bus bars without the help of a storage battery or some form of balancing set tiding over the voltage drop caused by the severe fluctuations of the motor currents.

In every design it is important to realize that a chain of operations goes on in each plant, and to pay close attention to the relations of the different machines and processes which make up the sequence. This is as true in technical education as it is in a factory, and one of the best founded criticisms of modern engineering schools is based upon the apparent lack of relation between the different subjects which make up the curriculum, in so far as those subjects are studied in detail. That is to say, the mathematical problems which are given to students often have no more bearing upon any phase of engineering than the annual rainfall in Colorado has upon the depth of Massachusetts Bay. In every department of engineering the condition of success is a sense of the true proportions of things.

While it is true that practically every design is the result of a judicious series of skilled compromises, there is scarcely ever completed a design without certain defects which teach an important lesson, useful in the laying out of future work. It is always worth while to approach a new plant in a spirit of friendly criticism, keeping an eye out for bad features of construction as well as good ones.

One of the most common defects encountered in electric plants is the lack of provision for any sort of fire-extinguishing apparatus. Innumerable sub-stations and generating plants have been installed with due regard to the best prevailing practice in fire-proof building construction, concrete floors, brick walls, etc.; the high and low-tension wiring has been carefully insulated and separated—and there the matter has rested. One looks in vain for a single extinguisher, sand pail or asbestos blanket. There is no excuse for such a penny-wise and pound-foolish policy, and it would be hard to point to a better example of false economy. Fires are likely to occur in even the best designed stations, and it ought to be everywhere recognized that the installation of sufficient apparatus to extinguish every fire within the first moments of its existence is a duty of tremendous importance. It is well worth while to use shutters, wired glass or asbestos curtains at the windows of every plant exposed to external hazards.

The practice of building the walls of a station after the machinery has been set upon its foundations sometimes results in much inconvenience if a doorway is not left large enough to permit the egress or entrance of the largest single piece of apparatus which is to be used in the plant. This is an

oversight often committed in railway sub-stations, which are left without the means of taking the rotaries out in case of necessity. Then again, the permanent facilities for handling such machinery are often of the most meagre character.

Recently the writer visited a rotary-converter sub-station of 1000-K. W. rated capacity, and found in it absolutely no provision for the handling of heavy pieces of machinery other than that afforded by a single steel I-beam, which crossed the rotary room at right angles to the path that would be followed in getting the machine parts out of the building. It is easy to see the inconvenience and loss of valuable time which would accompany an accident to the machinery, necessitating the return of one of the armatures or parts of the field frames and magnet spools to the factory. At such times delays are serious in heavily loaded plants, and it would seem that a capacity of 1000 K. W. should warrant the installation of a hand-operated travelling crane, although economy might forbid the purchase of a power-driven traveller. As for getting the transformers out of the basement in this sub-station in case of burn-outs or fires, there was no apparent method, except the use of special block and tackle rigged to the roof girder mentioned in the rotary room. The transformers could only be moved to the floor opening by the most laborious use of skids and chains.

In large transmission plants the idea of setting the transformers on rollers running on tracks is meeting with favorable consideration, so that in case of trouble they can be rapidly transferred to other quarters. A recent design carried the tracks from the transformer room through fireproof doors in the separating wall into the main generator room directly under the travel of an electric crane capable of handling the largest single piece of each alternator.

Great diversity in wiring methods is encountered as one visits installations throughout the country. It is surprising to note the number of designs which render this important part of a plant inaccessible, or, at least, difficult and dangerous to repair. In a recent instance, the high-tension wires were carried from the entrance of the building to the oil switches, through a brick chimney but 18 inches wide, no access whatsoever being provided, except at the top and bottom of the shaft, while the lightning arresters were installed within 2 feet of the floor, with bare metallic contacts ready to repay the most careless touch with deadly interest. Economy is not served by such designs as this. Whenever the location of a plant permits the installation of its wiring in what might be called a straight line sequence, the possibilities of interruption, delays and fatal accidents are much reduced if the designer follows this plan in laying out the successive stages of apparatus. The real sub-station for high potentials thus brings the high-tension line into the building on one side, carries the current in regular progression past lightning arresters, through the high-voltage switches, transformers, rotaries or motor-generators and direct-current switches, and thence to the low-tension line by way of the opposite side of the building. There is little opportunity to make mistakes in overhauling the wiring of such a plant, and in places where real estate is cheap, it is economy to avoid all unnecessary bunching of apparatus.

The question of space is always serious in isolated plants or central stations located in the congested districts of cities. It is only in recent years that architects have given proper consideration to the requirements of the electric plant in office buildings, hotels, apartment houses, etc. The idea used to hold place that any dark, unwholesome basement corner, large enough to hold a packing case, would do for the electrical machinery. Modern practice has changed all this, however, and the plants most recently designed for city use show signs of a much more liberal treatment. It is impossible to provide more than a minimum of space, at the best, in localities where every square foot of ground is worth from $10 up, but care can at least be taken that space which rightfully belongs to the plant shall not be usurped by less valuable features of the building. Often the store-rooms can be built with deeper cellars than the plant requires in order to give the machinery and boilers a few square feet more of room.

Break-downs in office-building, hotel and apartment plants always demand speedy repairs, and it is very important that enough room be included in the layout to permit the easy handling of engines, boilers, generators and switchboards. In this connection the question of illumination enters with peculiar force. Countless plants are improperly lighted by widely scattered incandescent lamps, the bulbs being so spotted with oil and dust that half or two-thirds of the rated candle-power is lost. The enclosed arc lamp is well adapted to isolated plant lighting, and its use in place of incandescents is well worth careful consideration. It is folly to expect an engineer to make quick and effective repairs of a delicate nature or to set engine valves in a miserably lighted plant, and it has long been recognized that one of the surest ways of allowing dirt and oil to accumulate is to provide poor illumination in engine and boiler rooms.

Lamps should be supplied in sufficient quantity to allow every inch of piping to be easily examined at regular intervals, and the use of white-washed walls, foundations and other brick-work pays expenses every time in its influence upon the depreciation factor. Highly ornamented plants, such as one sees in some portions of Europe, and in some instances in America, generally represent a waste of money, for it is certain that a properly designed and maintained plant will be sufficiently ornamental in its adaptation of means to ends to render needless any particular expenditures in the way of gilt and high-colored paints

The piping question has yet to receive the attention which it deserves in every class of electric plant. Perhaps no portion of a station is the source of greater possible waste through condensation, radiation, leaky joints and connection. The best practice of the present day aims at the utmost possible simplicity in design, with as little duplication as will insure continuity of service. If a storage battery is to form part of the equipment, the piping may be made still more simple and direct through the repairs which the battery permits without entire interruption of the service. It would scarcely seem necessary to point out the importance of carefully lagging every heat-carrying pipe in an installation, and maintaining that lagging in good condition, were it not for the glaring instances of carelessness in this respect which confront one in practice. In short, the piping system offers a fertile field for the introduction of economies, and it emphatically cries out against a wide-spread neglect in innumerable operating installations of the present day.

The boiler plant stands a close second to the piping scheme in this respect, but it is gratifying to note an increase in interest on the part of managers in this fundamentally important part of their systems. Not long ago the writer inspected a boiler room which contained nearly 4000 H. P. in equipment, lighted solely by two arc lamps of the old open type. It is no wonder that a fireman's life is a burden under such circumstances. No automatic stoker or economizer was installed, and all through the steam end of the plant, back of the engines, leaks of water and oil were frequent.

One cannot expect a plant to be properly maintained where so little care is taken to provide proper light and reasonable comfort for the employees.

A common fault in the equipment of sub-stations which is the cause of continuous inconvenience is found in the failure to provide sound-proof booths for the telephones. Continuity of service is a vital feature of operating success, and in times of emergency the telephone assumes an importance difficult to express in a single sentence. Every instant's delay, caused by the roar of machinery in the ears of the attendant, who is trying to make himself understood and to hear instructions from the "other end," may easily mean a financial loss to the operating company far greater than the mere cost of a sound-proof booth —generally a matter of from $30 to $50, at the outside. This sin of omission is very common, and it is even sometimes planned to despatch cars by telephone from the very midst of a noisy sub-station. Imagine the possibility of a steam railway train dispatcher doing business in an unquiet room—apart from the noise of his telegraph instruments, of course.

The methods of handling coal are always worth the designer's best attention. Every successive handling between the barge or car and the furnace means expense. An instance of great inefficiency in taking care of the fuel supply was noted at a railway plant on the New England coast. There the coal barges discharged their cargoes into wagons at an inlet of the ocean, about 2 miles from the power house. The coal was then hauled the 2 miles by horses and finally dumped on the ground outside the station, three or four teams being constantly employed in the work. The route between the power house and the wharf lay alongside the company's trolley tracks for every foot of the way, and the station itself was located upon a tidal inlet. Why the company did not run a short spur track into the station yard, another to the wharf, and carry the coal in home-made coal cars of its own, was not easy to see. Even a moderate amount of dredging would probably have enabled the barges to discharge directly at the power station with greater ultimate economy than the unprogressive horse haulage of the fuel over the route of the company's own lines.

It is in cases like the above that the advice of a consulting engineer comes into play. Electrical and mechanical apparatus is to-day produced in such variety and adapted to so many different purposes that it is hazardous for the promoters of any extensive scheme of electrical work to decide upon these questions of design and operation without the advice of an expert in the particular branch in which they are investing their own or some one else's money. The false economy of dispensing with professional engineering counsel is not yet sufficiently appreciated in the business world.

A case in point is illustrated by the owner of an isolated plant for hotel service who recently installed 125 K. W. in engines and generators, only to find himself in a few weeks entirely at sea as to whether he had better enlarge his plant by adding another generator and engine or a storage battery to an equipment so underloaded in the daytime that the larger machine was not run for weeks at a time, and so busy at night that the elevators materially affected the lighting service. The consulting engineer's advice was conspicuously absent in this plant, and its economy of operation is yet to be demonstrated. Failure to appreciate the financial value of technical knowledge has cost boards of directors many a dollar in times past, and until still greater improvement in this respect is brought about by progressiveness, operating systems are bound to squander their earnings in preventable waste.

Switchboard design offers an attractive field for the practice of economy. Somewhat the same problems enter this phase of power plant construction, as are found in connection with the piping system. A comparison of modern switchboards with those of fifteen years ago discloses great progress in simplifying the arrangement of switches, instruments and panels. The devolopment of alternating-current practice has, of course, introduced complications unknown in the old days of wooden frames and cumbersome, slow-breaking knife switches; but even in the most advanced installation of the present day, one finds a duplication of panels, connections, bus bars, etc., which is mastered without great difficulty, and which steadily tends to depart from complexity in its arrangement. The larger the plant, the more likely are we to observe the designer's efforts to attain a simple layout of apparatus.

It is fundamentally important that all the portions of a switchboard are in harmony with one another as far as duplicate parts are concerned, and it is a good plan never to install any piece of the switchboard apparatus whose necessity has not been well established. The recent developments in alternating-current arc lamps and motors point the way toward a simplicity in switchboard design which was unattainable five or ten years ago, because of the great variety of currents which it was necessary for a station to deliver in supplying different forms of apparatus.

The fireproof construction is an imperative necessity in every economical design, and ample space is a requisite in handling high-tension currents of every voltage. One does not often find switchboards of modern plants installed so close to the wall that nothing short of a human skeleton can work behind them with safety and convenience, but a large number of operating stations are old offenders in this respect, and in the interests of broad economy should be modified.

Provision for expansion is a matter which sometimes falls short of proper consideration in plant designs. Frequently the limitations of real estate absolutely determine the size of an installation, but generally some sort of allowance can be made for future growth. Last year the writer ran across a new electric railway plant in Massachusetts which had installed two boilers directly under a large gravel bank, carrying the highway and trolley lines—an arrangement which absolutely limited any sort of extension in the direction in which the plant had been laid out. Local conditions in no way interfered with the proper planning of the engine and boiler rooms, and the plant might have been turned, without the slightest difficulty, at right angles to the original design, perpermitting a symmetrical expansion for many years to come. This same plant commenced operation with second-hand, horizontal, non-condensing engines, belted to generators about twelve years old, the engines themselves having been used in one of the earliest electric railway installations of New England.

It is scarcely necessary to add that the entire plant was designed and built by a street-railway promoter, whose knowledge of engineering was ridiculously small, and that the road is today reaping the reward of ignorance in its operating expenses. Every time the fireman shovelled coal he was obliged to climb upon a terrace some 18 inches above the boiler room floor, and the handling of ashes was all done by wheelbarrow up a plank at an angle of some 25 degrees to the horizontal. No crane was provided in the engine room, the steam piping was a puzzle of surpassing intricacy, and the power supply so weak that the cars nearly always balked at a 4 or 5 per cent. grade, and had to take it by a sort of flying start.

It is astonishing to find plants in operation the country over which spend large sums to secure economy in apparatus, and then overlook some

feature in the chain of energy transformations from fuel to overhead lines which distinctly neutralizes the economy of the machinery. An instance is found in a municipal oil-engine plant, in which an advanced and most efficient type of engine was adopted, belted to the generators instead of making a direct connection and securing the highest degree of operating economy.

Still another plant—a large electric light station, which supplies a city of over 100,000 inhabitants—drives its dynamos through long lines of energy-wasting shafting and pulleys, without much realization of the possibilities and status of the alternating-current arc lamp. The writer has never known of two alternators being operated in parallel in this station, and although the original load of arc lamps, supplied from Thomson-Houston machines, demanded the shafting and belting, it would seem that the progress of recent years in alternating lighting would now justify a change to direct-connected units. It is only fair to this station to say that it has now installed one direct-connected alternator, and that its engines and general construction have always held a high reputation among electric lighting experts.

In the design of isolated plants, particularly abroad, there are many instances of installing generators partly below the floor level of the engine room, in such a manner as to render the lower part of the field difficult of access in case of trouble. It is not too much to say that any such design, which introduces inconvenience in making quick repairs, deserves severe and unfavorable criticism.

Passing to the operating phases of electrical work we find an unlimited field for the saving of money. Broadly speaking, everything which an employee does affects the company's welfare in exact proportion as it is done well or poorly. As a foundation for good work, the comfort of employees deserves close attention. In the matter of sub-station location, for instance, it makes little difference in the operating economy of a transmission line whether the sub-station is built within a mile on each side of the theoretical location, but it sometimes makes a great difference on the health side of the case. Then, too, the provision of suitable drinking water and toilet arrangements is often left to mere chance. The same point in regard to location economy applies to moving the sub-station to some car house, junction point or ticket office where attendance is regularly at hand. Beyond starting the machinery in the morning, stopping it at night, and giving it an eye from time to time during the day, putting down instrument readings, etc., there is not very much to do in a sub-station as long as everything goes all right. For this reason it is a source of economy for an operating company to be able to ultilize the services of its sub-station employees in more than one direction, and this is now well recognized in the electric railway field.

It is not uncommon, in localities where power is cheap, to find incandescent lamps burning out of doors in broad daylight. Some of the mining regions in Colorado are especially prone to encourage depreciation in this way. Even though the water-power from which the current is derived spills away considerable inexpensive energy, the question of lamp depreciation stares us in the face and offers a chance to save the small sums which aggregate the grand total in yearly operating expense.

Successful operation in any electrical system depends largely upon the quality and care of the materials used in its construction. For this reason, specifications and plans ought to be complete in detail whenever any new conditions have to be overcome in carrying out new work, and careful tests of both construction materials and machinery should be made during the manufacture and building of the plant, as well as after beginning operation, and before final payment upon contracts is made. Perpetual observation is synonymous with economy.

Thus, in an electric railway system it is necessary to keep a constant watch on all running machinery, the wear and tear of parts, consumption of supplies, coal, oil, waste, etc., the usage of power, light and heat, leakage of current, steam consumption of engines, electrolysis of underground structures, distribution of copper in the feeder system and handling of coal. In a factory which turns out thousands of electrically-baked crackers each hour, it is of like importance to keep a steady tally of the watt-hour consumption per cracker, or for a unit of product like the box of crackers, so that any excessive consumption through deterioration in the electric stoves can immediately be remedied. All records of this character can be so easily made clear by plotting them in curve form that this should be done wherever it is possible. Gross earnings, operating expenses, net profits—every factor in the process of turning out dividends, can be followed with infinitely greater facility by the use of graphic methods.

The filing of correspondence, drawings and data affords an excellent opportunity for the practice of economy in every electrical establishment. Experience has shown that it certainly pays to spend a little time and care in classifying and recording every separate record which enters or leaves an office. This is the opportunity of the card catalogue, and its increasing use throughout every electrical industry is an indication of its time and money-saving qualities.

In closing these comments on economical methods of operation we must not lose sight of the effect of accidents and poor service upon profits. It would be hard to find a more important factor in successful operation than excellent service. Every branch of electrical work illustrates this point, and none in a more striking manner than telephony. Not only does business increase in direct proportion to the facility with which it is heralded, but the whole community's welfare is augmented or contracted by the quality of telephone service with which it is supplied. In the field of urban transportation it has long since been recognized that traffic never fails to outrun every new provision for its handling, and nowhere can we find a better illustration of the financial cost of even the most petty accidents than upon the electric railway. The electric light company which allows its overhead circuits to become ragged and flimsy, to some day kill a man by the wires falling, the street railway whose motormen fall below par in their adherence to standards of good car operation, and the telephone company which omits to protect the crossing of its toll lines by high-potential transmission circuits, these, and all other organizations, parsimonious in their maintenance departments, reap their reward in heavy damages sooner or later. Continuous, safe service is the "sine qua non" of lasting commercial success.

The writer is well aware that some of the foregoing points have been brought to light before in the engineering world, and that many things have been left unsaid which bear directly upon both designing and operating economy. None the less, it is believed that only by constant consideration of these sources of needless loss will improvements be effected in the manner of conducting electrical enterprises. The problem of getting the most out of a given expenditure of labor and capital confronts the vast majority of human beings to-day living in the civilized world, and in just so far as every unnecessary waste is perpetually fought into the corner, so far will good engineering be accomplished in electrical design and operation.

It is estimated that the electrical engineering industry in Germany provides employment for 69,000 workers and officials.

Terminals and Bushings for High-Pressure Transformers

By WALTER S. MOODY

A Paper Read Before the American Institute of Electrical Engineers

THIS subject will include cables, straps, connectors, etc., for both high and low-tension side, designed both for terminal connections and for changes in the ratio of transformation, together with their insulation. In transformers for moderate pressure and having but two high and low-pressure terminals, the problem of terminals is a simple one; with higher pressures and numerous changes in the ratio, however, the design of these parts of the transformer often becomes a most difficult problem upon the proper solution of which depends, to no small extent, the reliability of the transformer.

LOCATION OF TERMINALS ON COILS

It is much better to have the high and low-pressure terminals at opposite ends of the structure, for it is almost impossible to keep safe distances between the terminal and connecting coil leads, when all are at one end. In a shell-type structure, having its coils in vertical position, this requires one set of coil terminals to be at the bottom of the case, but to bring these safely to the top is not as difficult as to separate high and low-pressure conductors that are at the same end of the windings.

INSULATION OF TERMINALS ON COILS

In an oil-immersed transformer, this presents little difficulty, as it is simply necessary to have all leads spaced a safe distance from each other and from the coils, and covered with sufficient waterproof insulation to prevent any moisture penetrating the coil around the terminals before the oil is put in.

In air-blast transformers, however, the case is different; here all terminals must be covered with an insulation integral with that on the coil itself, to a distance from the coil that provides sufficient surface insulation, even when the lead is well covered with dust and dirt.

Often the dielectric strength of a transformer is materially lowered by allowing the coil-terminals or taps to project beyond the sides of the coils, thus shortening the distance between the primary and secondary. "Spreading" the exposed ends of the windings removes this difficulty, except when the terminal comes from a point well within the coil, but introduces a more serious defect, lack of rigidity to withstand the strains of short circuits. Usually the problem can be solved by so winding coils as to have only outside terminals and locating such coils as have taps on the outside of the coil structure.

LOCATION OF MAIN TERMINALS

The best location for these naturally varies with the type of transformer and its pressure; for the air-blast type, the air-chamber forms a convenient and natural location for the low-pressure wirings, and the terminals of these are therefore usually located in the base of such transformers and made accessible by doors in the side of the base. For pressures not exceeding 25,000 volts, the high-pressure wiring can also be placed in the air-chamber, without making the air-chamber of excessive cross section, so that all transformer terminals are in the base and exposed wiring is avoided. Heavy rubber-insulated cable is to be avoided in such construction, however, for should the rubber take fire from short-circuit or other causes a draft of air will carry the fire along the duct into the transformers with great rapidity.

In oil-filled transformers the terminals are, of necessity, located at or near the top of the case. Often for convenience in external wiring, projecting pockets are provided through which terminal-leads may leave the case in a downward direction. With such construction, it is necessary to have a solid section in the cable, just above the oil line, and to have this section uninsulated or covered with an insulation impervious to oil, otherwise the cable and insulation will act as a siphon and discharge oil.

INSULATION OF MAIN HIGH-PRESSURE TERMINALS

Below 40,000 volts, the insulation of terminals offers no special difficulty; porcelain or glass bushings can readily be obtained that are safe for this pressure, even if the conductor has no insulating covering. For higher pressures, the problem is more difficult; if no insulation is used on conductors, the bushings become expensive and so large that there is scarcely room on top of a moderate size transformer for as many terminals as are often required. The following are some of the more common forms of bushings that have been used:—

Wooden tubes.

Hard-rubber tubes.

Glass and porcelain tubes, both single and concentric.

Numerous forms of molded porcelain bushings.

Wooden tubes of the necessary size cannot be thoroughly dried and filled. Hard rubber is so apt to contain impurities that it is unsatisfactory; moreover, it deteriorates rapidly if ozone is generated near it. Glass is fragile and must be protected with other semi-insulators. Porcelain, or any smooth tube, must be very long if it have sufficient leakage surface to be safe when dirty, and even the best shapes of corrugated bushings are large and expensive when capable of withstanding a test of from 75,000 to 160,000 volts.

All things considered, the writer has found the following practice quite satisfactory for test-pressures not exceeding 160,000:—

Insulate the lead with varnished wrappings that will safely withstand for one minute about half of the test pressure to be applied, bringing out this lead through a porcelain bushing having the same strength as the insulation of the lead, and sufficient surface to prevent leakage at this pressure when dirty; in other words, let the insulation of the leads be sufficient for the working pressure, and the porcelain be of such strength as to give the factor of safety desired. This combination forms a far safer insulation than a bare conductor and a larger bushing which would stand the same puncture test as the combina-

tion, from the well-known fact that oxidized linseed oil is an insulation that will momentarily stand several times as much as it will for any considerable length of time, while porcelain, glass, etc., have no such time-factor.

In leads requiring a test of 100,000 volts or more and insulated in this manner, an additional difficulty is met in the induced charge on the outer surface of the insulation; at this pressure the surface is covered with a heavy brush discharge that so reduces the surface resistance to leakage that 100,000 volts will travel along several feet. It is usually impracticable to make the insulated lead long enough to withstand the pressure under these conditions, but the discharge may be broken up, so that it will not appreciably reduce the surface resistance, by bell-shaped pieces of rubber, porcelain or other insulation slipped over the lead before all the varnished wrappings are put on, and having its small end so shaped as to allow of its being burned in the outer wrappings.

In transformers designed for Y-connection and grounded neutral, some transformer builders, in order to save expense on high-pressure bushings, have grounded one terminal on the case and insulated only such leads as are to be connected to the line; this prevents operation with Δ connections, but otherwise seems unobjectionable. In similar manner, the use of three-phase transformers with the inter-connecting between the phases made within the case reduces the expense and possibility of trouble with bushings.

Eighty thousand volts is the highest pressure that is now practicable for transmission work, but the transformers and insulators must be tested; consequently there is some demand for transformers working up to 200,000 volts. The insulation of the terminals of such transformers is the most formidable part of their design. As yet, I know of no satisfactory solution of the problem except to use oil-filled tubes as terminals. A terminal that has withstood 375,000 volts without any indication of weakness is constructed as follows:—

The tube was in the shape of two truncated cones, bases together; about 12 inches in diameter at the center, and 4 inches at each end; it was built up of thin, wooden rings, telescoped a short distance into each other, and held together by the conductor, which, for mechanical purposes, was made quite heavy, and which was located in the axis of the cones and supported by washers at each end of the tube; between each section of the tube were collars of insulating material, three inches larger in diameter than the tube, which served the purpose of greatly increasing the leakage surface. After the sections were drawn tightly together by nuts at each end of the conductor, the whole structure was repeatedly dipped in varnish and dried, thus sealing all joints. The terminal was mounted with the lower end several inches under the oil in the transformer and with its largest diameter on a level with the cover; the lower end of the tube was tightly sealed, making the tube perfectly oil-tight.

INTERNAL TERMINALS

At present we are passing through a period of development in line construction. Each engineer of a new transmission system of considerable length desires to use as high pressure as possible with a line construction of reasonable cost, but few are sure whether 50, 60, 70 or 80 thousand volts are the safe maximum for their conditions. It is common, therefore, for the manufacturers to be asked to make transformers that can be operated at several voltages on the high-pressure side. The result, whether accomplished with series-multiple connection, changing from Δ to Y, or simply by taps, usually requires so many terminals, that it becomes quite impracticable to place all the necessary leads outside of the case, even were it desirable to do so; consequently, accessible terminals inside the case must be provided. Again, at these and lower pressures, also, it is usually desirable to provide for limited range of adjustment in the ratio, say by 2 per cent., with a total of 10 per cent.; such changes are usually too small to be made except by means of taps on the high-pressure windings. Except in transformers of very large capacity, there would be no room safely to insulate so numerous terminals above the surface of the oil; the practice is, therefore, to locate such terminals just under the oil and make them as accessible as possible, either by the removal of the transformer top, or through an auxiliary cover on the top of the case. It is better that each of these terminals be separately supported by glass or porcelain insulators, for a single support, such as a slab of marble, is almost sure to collect sufficient semi-conducting material to cause trouble sooner or later. Such terminals being, at the best, rather inaccessible, there is danger that a wrong or imperfect connection will be made when changes are desired; the following method of mounting transformers in the tank greatly simplifies the problem of getting at such terminals, especially when transformers are installed under a crane:—Instead of supporting the transformer proper on the base of the case as usual, it is hung from a strong cover; the interior terminals are placed in about the usual position, but are supported by the bolts carrying the transformer. To get at these terminals it is then simply necessary to raise the cover with the transformer, until the terminals are on a level with top of case; connections may then be made with convenience and safety and the transformer returned to its position in the tank.

LOW-PRESSURE TERMINALS

Usually these present no special difficulties; when transformers are connected in multiple and deliver 500 amperes or more, special caution ought to be taken that all joints are soldered or that terminals are of such construction as to have extremely low contact resistances. Taper plugs and receptacles are perhaps the most reliable form of contact for the purpose.

Current in excess of 500 amperes ought never to be brought out through separate openings in the case, otherwise there will be local heating around the terminal and needless reactance introduced into the circuit. Currents over 2500 amperes ought to be brought out by means of intermixed bus-bars for the same reason.

Electric Plants in Foreign Countries

The City Council of East Retford, a place of over 10,000 inhabitants in Nottingham County, England, is contemplating the building of a municipal electric light and power plant.

The Municipal Council, of Rochdale, a borough of about 75,000 inhabitants in Lancashire County, England, is planning to spend a sum which will exceed $200,000 in enlarging and improving its electric plant.

The municipal authorities of Barcellos, a small place on the Cavado River, about 25 miles north of Oporto, Portugal, are willing to grant a thirty-year concession to a company for the erection of an electric light and power plant. One of the stipulations which will be exacted of such a company will be that it furnishes the municipality with 160 16-candle-power incandescent lights and six 50-candle-power arc lights for the sum of 1500 milries ($1620) per annum.

The Schaffhausen-Schleitheim Electric Street Railway, of Schaffhausen, Switzerland, is reported to be in the market as a purchaser of rolling stock.

THE ELECTRICAL AGE

Volume XXXIII Number 2
$2.50 a year; 25 cents a copy

New York, August, 1904

Entered at the P. O. as 2d-class matter. Copyright, Louis Cassier

ESTABLISHED 1883

Published monthly at 3, 5 and 7 W. 29th Street, New York City.
Telephone No. 1617 and 1618 Madison Square. Private branch exchange connecting all departments. Cable Address—Cassier, New York.

SUBSCRIPTION RATES

The Electrical Age will be sent post free anywhere in the United States and its possessions, Canada and Mexico for $2.50 per year, single copies 25 cents. To Great Britain and all countries embraced in the postal union, $3.75, 15 shillings, 19 francs, 15 marks, or 10 rupees. Send subscriptions to our nearest branch office or agency.

NOTICE TO ADVERTISERS

Insertion of new advertisements or changes of copy cannot be guaranteed for the following issue if received later than the 15th of each month.

LONDON OFFICES

Business Department, 33, Bedford Street. Editorial Department, 22, Henrietta Street. Covent Garden, Strand, W. C.

London Telephone, Post Office, 3807 Central. Private branch exchange. London Cable Address—Revolvable, London.
All remittances to London Office should be crossed London and County Banking Company.

BRANCH OFFICES AND AGENCIES

Subscriptions may be sent to the following branch office or agencies, where they will receive the same careful attention as at the home office in New York:

124, Queen St., Melbourne
359, George St., Sydney
61, Main St., Yokohoma
23, Esplanade Rd., Bombay
33, Loop St., Cape Town
Unter den Linden, 5, Berlin
Nevsky Prospect, St. Petersburg
31, bis rue de Fauburg Montmartre, Paris

General Agents for United States and Canada: The American News Company

Leading Articles

Trolley Cars in Other Climes. By Alexander Hume Ford ... 81
Electric Locomotives. By J. F. Gairns ... 91
The Electrical Fire Hazard. By J. C. Forsyth ... 104
Electrolytic Meters. By H. W. Young ... 106
New Applications of Electric Motors at the St. Louis Exposition. By Cloyd Marshall. 111
Finances of Electric Railways. By Wm. D. Marks ... 117
Lightning, Its Causes and Effects. By H. W. Spang ... 121
Some Points in Electric Station Design and Operation. By Howard S. Knowlton ... 124
Terminals and Bushings for High-Pressure Transformers. By Walter S. Moody ... 128
War News by Wireless Telegraph ... 130
The Future of the Rotary Converter ... 130
Wireless and Submarine Telegraph Competition ... 131
The Telephone and Telegraph in Warfare ... 131
Electricity in the Philippines ... 134
A 100-Mile Electric Transmission Line. By Robert Howes ... 135
Electric Transmission Lines. By Alton D. Adams ... 145
The Drafting Room Apprenticeship Course of the General Electric Company. By John W. Upp ... 157

War News by Wireless Telegraph

THE operations of the Chinese steamship "Haimun," which was chartered by the "London Times" and equipped with the DeForest wireless telegraph system for the purpose of gathering news in the war zone in the Far East, were watched with much interest, and it must be admitted that her career in this respect, while comparatively short, was highly successful. The reason given for the sudden cessation of operations was that the steamship required repairs and had proceeded to a Japanese port for that purpose. It developed later, however, that the movements of the vessel had been restricted by the Japanese Government to points south of Pillar Rock on the Chinese Coast, which restrictions had the practical effect of putting the "Haimun" out of commission. One reason for placing these restrictions on the movements of the vessel is said to be that the "Haimun's" wireless transmission interfered with the Japanese wireless operations up to a distance of 100 miles.

Another possible explanation may be that the news gathered, or that might be gathered, by the "Haimun," as to the operations of the Japanese, and sent out to the four corners of the earth by cable, from Wei-hei-wei, where the wireless shore station was situated, did not accord with the well-established policy of the Japanese and, indeed, all naval and military authorities, to conceal their actions in every possible way from the enemy. If this policy prevails hereafter, as no doubt it will, the gathering of war news by wireless telegraphy or otherwise may be as difficult a matter at sea as it now appears to be on land.

The Future of the Rotary Converter

WITHIN the past year or two the alternating-current railway motor has received more attention than at any previous time in the history of electric transportation. Much money is being spent to produce a machine which shall be capable of supplanting the direct-current motor in every phase of car service, and it is generally agreed that the next five years will witness some very important changes in electric railway practice.

Doubtless alternating-current car equipment will score its first triumphs upon new roads, rather than upon established operating systems. The present methods of handling railway traffic by electricity have been developed to a high pitch of reliability, and it is going to be no easy task to dislodge the direct-current motor from the sphere it has so long and so acceptably filled. Enthusiasts have not been lacking to declare the approaching dissolution of continuous-current railway equipment, except the exciter sets in the power house, the rotary converter especially being singled out as a passing type of machinery.

No one can deny that the elimination of all moving mechanism in the railway sub-station means greater economy in both operating expenses and fixed charges. The cost of attendance in a 300 K. W. sub-station valued at, say, $20,000 practically doubles the investment when capitalized. Even though the larger part of the work demands little, if any, skilled knowledge the importance of preventing and cutting short any breakdowns in the revolving machinery and its connections requires the payment of the wages due to a high degree of intelligence on the part of employees.

The broadest economy justifies such an expense, but as long as everything runs smoothly it seems a good deal to pay two men $1200 or $1500 a year to start the machinery in the morning, stop it at night, keep the sub-station clean and take occasional readings from the switchboard instruments in the day time. Inspection, rather than attendance, will be required by the simple transformer sub-stations which will be expected in the future to supply current to the motors of roads using alternating-current car equipment. One or two men can easily look after a dozen sub-stations, if need be, riding from one to the other upon the cars of the company which employs them.

In a purely alternating sub-station the air-blast transformers will require about the only moving machinery, and it is well known that the attendance necessary to keep small induction motors in order is exceedingly small. By using poly-phase transformers the sub-station space may be cut down 20 or 30 per cent. in large installations,

and a greater efficiency of equipment secured, although the single-phase motor modifies this advantage.

As far as the sub-station is concerned, it is easy to make out a strong case against both the rotary converter and the motor-generator, but there are several important difficulties to be overcome before the rotary converter will disappear from sub-station practice. In arraigning the series alternating single-phase railway motor, a fairly long list of charges has been made out against it, one of its most serious defects having been mentioned as being the low voltage which it bids fair to require in operation.

It is generally understood that two motors must be run in series upon 500-volt circuits; the commutation is scarcely superior to that of direct-current types; the field-spools usually have a higher voltage per turn and an insulation failure means heavy induced currents not found in the direct-current motor; the internal losses run from 15 to 35 per cent.; the efficiency is from 1 to 5 per cent. lower than in continuous-current machines; the power factor is low in acceleration; if the distribution system is high-tension throughout, heavy transformers and regulators have to be carried as dead weight on the cars; the motor is heavier and something like 50 or 60 per cent. more expensive than the direct-current equipment; single-phase generators are more expensive by 30 per cent. than poly-phase alternators; low frequency transformers are more costly than present types, and, finally, depreciation and maintenance are likely to exceed the cost of up-keep in direct-current railway machinery.

It is probable that extensive improvements will be made in the alternating railway motor, but unless some very marked saving can be shown in the cost of the distributing system that is not overbalanced by other defects, it is not easy to see wherein the direct-current railway motor is less economical than the alternating; and upon a continued demand for current transformation from alternating to direct forms rests the future of the rotary converter, and also of the motor-generator. The development of a high-voltage induction railway motor for car service, independent of carrying around heavy transformers, would threaten the rotary converter far more than does the advent of the low-voltage, single-phase machine.

As a current reorganizer the rotary has an efficiency equal to the best modern dynamos—well above 90 per cent. and often 93 or 94 per cent. It is cheaper to build than the motor-generator, and almost always sells for from half to two-thirds the price of the latter, although at times special prices are made on motor-generators, a case in point being that of an interurban road which paid but $19 per K. W. for each of six 300-K. W. sets. This price, however, was made largely to induce the road to adopt a system of multiple-unit control which had been upon the market but a short time.

As long as there is a demand for direct-current supply in either interurban or city railway service, the rotary converter will probably occupy an important place in the equipment of electric railways. It has been developed after many experiments and designs to a point where it is a thoroughly reliable machine. The larger sizes, from 500 to 1500 K. W., are seldom built for frequencies as high as 60 cycles, because when the power requirements are of this magnitude it is generally advisable to adopt a frequency in the neighborhood of from 25 to 40 cycles. The weights of a familiar type of rotaries in pounds per K. W., between the 1500 and 100 K. W. sizes, vary only from 73.5 to 105 pounds—an evidence that designers have pretty well crystallized their ideas upon these machines.

According to the present outlook, the rotary converter promises to remain in actual service and upon the market for some years to come.

Wireless and Submarine Telegraph Competition

LOOKING back to a period of about four years ago, it is difficult to realize the panicky state of mind into which the directors and shareholders of submarine cable companies were thrown by the reports of successful transatlantic wireless telegraphy at that time.

There were cool heads then, of course, who pointed out that the displacement of submarine cables by the wireless system was not even a remote possibility; but as is usual in panic times, many cable shareholders lost their heads and disposed of their holdings at a sacrifice. It is very interesting to note the the equanimity with which this subject of wireless telegraphy is now discussed by those same people, as exemplified in certain remarks of the chairman of the Eastern Telegraph Company at its last half-yearly meeting in London.

Among other things, he said, that while holding the view that wireless telegraphy will not compete with long-distance submarine telegraphy, yet there are certain places where wireless telegraphy can be usefully employed, and he cited a case in point in the Azores, where some of the submarine cables now touch. Portugal has long desired that some of the outlying islands should be placed in telegraphic communication, but, owing to the nature of the sea bottom and the landing places of these islands, they are not considered suitable places to make the connection by cable, neither would the traffic warrant the expenditure for a cable. It is, therefore, intended to connect the points by a system of wireless telegraphy, to be worked in connection with the submarine cable system. This and similar uses of wireless telegraphy are the ones which deserve hearty commendation.

The Telephone and Telegraph in Warfare

FROM the time of Napoleon until quite recently the power of Russia has been respected, even feared, by all nations. The average mind was stunned by the thought that the White Czar, by lifting his hand, could place over two millions of soldiers in the field to defend Russia or overrun the territory of other nations. Russia's navy, too, was highly rated. Within a few months there has come about that which has dissipated our mental numbness in regard to Russia's power. We are now most impressed by the seeming ease with which a relatively small nation like Japan may render large numbers of armed men well-nigh impotent for practical military purposes.

The strides which the science of war has taken in its grim progress during the last twenty-five years, and the terrible agents now available for the destruction of human life have forced a modification of the tactics of the past. The Japanese, profiting by the experience of other nations and developing through their own initiative, have advanced the science of war a step beyond any point reached heretofore. The extraordinary strategical combinations which they have made in the war now on with Russia are the greatest military marvel of modern times.

Their tactics, strategy, or military science, call it what you will, has blocked the advance of a world-power whose vaunted aggressiveness has led us to accept her army leaders as representing the fruits of generations of academic learning and military genius.

If war to-day were a matter of might and physical courage, as it used to be in olden days, when men fought with swords and battle axes, there would be little likelihood of Japan, against a nation like Russia, gaining even a single victory. In the use of hastily constructed fixed fortifications

THE TELEPHONE IN JAPANESE WAR SERVICE

and high explosives, and in the rapidity of fire of infantry and artillery, no advantage lies with the army of Japan. But the Japanese have to a far greater extent than the Russians called upon the inventor and the skilled electrician to aid their commanders on both land and sea.

It is in the application of the various means of communication and the skill and resource of its signal service corps that the Japanese army has shown its great superiority over the Russian. Its victories have been due chiefly to the comprehensive utilization of the telegraph and telephone, particularly the latter.

It may not occur to the lay mind, although it is the experience of soldiers, that it is frequently far more difficult for a commander to keep in touch with all divisions of his own command than to secure accurate information concerning the movements of the enemy. The Japanese signal men are adepts in the use of all the accepted methods of signalling, but, as has been intimated, they rely chiefly upon the telephone for intercommunication between the various divisions of the army.

By the use of rapidly laid telephone lines, known in military circles as flying telephones, the Japanese commander keeps himself at all times informed about what is taking place along his whole front and at his most distant outposts. He is thus enabled to make his dispositions more intelligently, as he can order the movement of his troops to meet all contingencies.

At every camp the Japanese establish a temporary telephone exchange with a special cordless switchboard which connects with the commander's headquarters, and through the headquarters exchange with seashore stations. The shore stations have direct communication with the War Minister in Tokio, who, by means of wireless telegraphy, keeps in touch with the fighting ships. Thus no part of the Japanese force is ever isolated. Even the scouting parties unreel their telephone lines as they advance, and are thus enabled to report their observations to the officer under whom they operate without the necessity of sending messengers back to headquarters. It will readily be seen that this saves much time and is of incalculable advantage in scouting by night.

Wherever it is possible, the telephone lines are laid upon the ground from a reel-wagon. When the scouting parties advance to a point where the wagon cannot follow without great risk, or over country too rough for horses, the observer and telephone operator continue to advance on foot,

A JAPANESE OUTPOST TELEPHONE STATION

the line being laid from a coil or reel borne on the shoulders of the operator. They may be accompanied by a guard or not, according to the exigencies of the occasion.

In the event of a surprise, or any other necessity for hasty retirement, the scouts simply cut the line and abandon it. Where there is a likelihood that a line can be maintained permanently, as, for example, to the rear of a large body of troops, a signal corps detail follows the reel-wagon and attaches the line to trees or lays it in protected places where it is less likely to be harmed.

It has frequently occurred in warfare, when the older and less adequate means of signalling had to be depended upon, that a movement which seemed well advised in view of what was transpiring at a given point, has proved injudicious,—even disastrous,—because of the conditions, unknown at the time, at another point. The Japanese commander can make no such mistake, for he is constantly kept informed of all that is transpiring at every point in his own command and of the movements of the enemy. Thus he can order an advance at one point or a retreat at another with the certainty that, so far as human judgment can go, he is making the best possible disposition of every division of his forces.

It is a question whether the introduction of skilled civilians, electricians, telephone operators and telegraphers and machinists will not have a tendency to discount the element of personal bravery in warfare, and it is interesting to speculate how far this evolution may be carried. When the spectacular feature is removed and the danger of surprise by the enemy and disaster through ill-timed advance or retreat is reduced to a minimum, war becomes commonplace, and its fascination for the man of simple courage is gone. It would seem to the ordinary mind that the ever-increasing deadliness of war, coupled with the diminishing value of the personal equation, must make for universal peace, for the war-spirit of all time past has been born of the hope of glory to be won through personal achievement, and not through a superior knowledge of scientific killing.

Advanced methods of warfare, as exemplified by the operations of the army of Japan, mean to the world far more than the settlement of the so-called Eastern question. They show that science will eventually make war impossible.

When the United States took hold of the Philippines it was with a vague notion of an undeveloped and promising country — one whose possibilities had still to be estimated. Now, after five or six years of actual possession, we have a very fair idea as to what the country can and cannot be used for and developed into. We have a street railway almost completed for the city of Manila, and telephone lines of an American type and degree of usefulness may soon supplant the wretched and entirely inadequate Spanish, Belgian and Danish instruments now in use in the capital. But the Philippines are so far away—half way around the globe—there are so many clamoring chances for judicious investment at home, and the conditions in the tropics are still so unsettled, that much money is not likely to be attracted thither unless the unusual transpires. The engineering difficulties in the way are considerable, and the climate is not such as to be inviting, so that altogether the chances of the islands for rapid physical development, with the accompaniment of the luxuries in mechanical, steam and electrical engineering, which make life so thoroughly livable elsewhere, are not encouraging.

Technical Instruction for Railway Telegraph Operators

A RADICAL deficiency, the one most common, perhaps, among telegraph operators, is the failure to acquire an understanding of the proper management of the switchboard and an adjustment of relays to suit changing atmospheric conditions. In a paper read before the Association of Railway Telegraph Superintendents recently, John B. Taltavall emphasized the fact that the importance of a thorough acquaintance in this regard cannot be too strongly impressed on the mind of the operator. Lack of such knowledge is a serious drawback. As every superintendent will bear witness, there are but comparatively few employees of the telegraph department on any line of railway who are able to make a patch or to test wires for ordinary faults, such as grounds, crosses or openings, to manage repeaters, and to balance duplex and quadruplex apparatus, now so extensively used on many railroad systems. Four operators in as many different offices on a well-known eastern trunk line were obliged to confess their ignorance a short time ago, as they were called up one after the other before a man was found sufficiently skilled to make a patch.

In another instance a day operator in a certain office understood how to patch, while the night man at the same point was unable to do so. The unequal conditions in the same office necessitating the occasional calling of the day man to the office during the night. These examples afford a too common illustration of grave defects respecting requisite technical information on the part of the operator, to remedy which for the benefit of the service might well become an imperative act on the part of the employing company. Printed instructions covering all switchboard practice, even when accompanied with blue prints, though of benefit to some, fail frequently, in their application to specified stations, to convey a correct understanding to others.

Especially is this true if the information be so voluminous and so general in character, too often the case, as to confuse and mystify the individual rather than enlighten him on the particular board regarding which his duties demand he shall have a clear conception. Now, if instructions, instead of being printed and sent to an operator, were rather more often taken to him, and their full meaning made clear by sufficient diagrammatic and oral explanation, the standard of excellence on the part of the individual would soon be in the ascendant, and the company itself would be the gainer thereby.

An interesting example of the manner in which nature adapts herself to the changes brought about by scientific and industrial development is reported from Brazil. In the State of Rio de Janeiro, a parasitical plant known as "Fillandsia" is very common, and its little hairy seeds are blown long distances in the air, taking root wherever they lodge. Among other points of anchorage, they have attached themselves to the poles and wires of the new electric lighting system of the town of Petropolis. Here they have grown with extraordinary luxuriance, covering the wires in many places with long green garlands, studded with red and white flowers; the unusual development is attributed to the strong light of the electric lamps.

According to a French authority, accumulator factories have a serious effect on the health. It has been found that forty employees in one factory had 802 days of illness from the effects of lead poisoning. At the same works in 1901, with twenty-five employees, the number of days of illness was 422. The mean annual days of illness of a worker from handling lead and its salts in accumulator factories are therefore nineteen.

A 100-Mile Electric Transmission Line

From Spokane, Washington, to the Coeur D'Alene Mine District

By ROBERT HOWES

Mr. Howes' paper was originally presented at the last annual meeting of the National Electric Light Association, but for its use here the author has added later available data and also the several photographic illustrations.—The Editor.

IN the following it is not the author's purpose to indulge in long explanations, descriptions or theories, but rather to give a brief description of the essential features of the plant and the transmission line, of the results obtained, and the difficulties encountered. The plant considered is that of the Washington Water Power Company, of Spokane, Wash. The power house is located at the foot of the lower falls of the Spokane River, in the very center of the city of Spokane. The theoretical head on the water-wheels is about 71 feet.

That portion of the plant which furnishes the power for the transmission line is composed of two Y-connected, 4000-volt, 2250-K. W., 60-cycle revolving field alternators, running at 300 revolutions per minute, each direct-driven from a pair of 40½-inch special turbines, made by the Stillwell-Bierce & Smith Vaile Company, and designed to develop 4000 H. P. under 68 feet of effective head. The water is supplied to each unit through a steel flume 10 feet in diameter and 500 feet long.

The wheels are governed by Lombard governors, with compensating action modified to meet the demands occasioned by the kinetic energy of the water moving in the long flumes. These governors can be relied upon to keep the speed from rising or falling over 3 per cent. from the normal with instantaneous changes of 600 K. W. at any position of the gates, and they will care for small changes of load to within one-third of 1 per cent. of normal speed.

The diagram on page 139 gives the important electrical connections. All instruments have been omitted to avoid confusion of lines; but a complete set is installed. Each generator is supplied with voltmeters, amperemeters and wattmeters in each leg, and the leads to the step-up transformers are also provided with amperemeters and a power factor indicator. By running one of the generators alone on the transmission line a complete set of instruments, voltmeters, wattmeters, amperemeters and a power factor indicator is available for that unit. All the electrical apparatus is of the General Electric Company's make, the indicating instrument being of the horizontal edgewise type.

The principal exciter is driven from a separate wheel, which is supplied with water from either of the two flumes. An induction motor, not yet in operation, is to be connected to the end of the exciter shaft, opposite the water-wheel, and driven from the transmission leads inside the oil circuit-breakers. It will serve the double purpose of governor and insurance against lack of power for the exciter if the chute-case of the water-wheel becomes partially choked up. An indicating wattmeter on the induction motor will indicate the choking of the water-wheel by showing that the motor is taking more load. The exciter will then be started and the choked wheel cleaned out.

The plant is designed to furnish three-phase current at 4000 volts for local power, and for step-up transformation to the end of the line, and 2300-volt, single-phase current for local lighting service in Spokane. Any lighting feeder can be thrown on any of the three legs of the Y-connected generator by means of the oil switches, and the load on the generators kept balanced. Hand-operated voltage regulators are installed on the neutral or grounded side of each lighting feeder, the voltage being regulated with the aid of a voltmeter compensated for the line loss.

The generator, transmission line and main city switches are motor-controlled. Those on the transmission line and city have automatic overload tripping devices. The city feeders have automatic oil circuit-breaker switches, hand-operated.

The step-up transformers are 750 K. W. each, and are of the water-cooled type. They are connected in delta on the 4000-volt side, and in Y on the high-tension side, the neutral connection being grounded at the power house. The high-tension winding is for 34,700 volts, taps being brought out for 26,000 volts also, thus giving a choice of 60,000 or 45,000 volts line pressure. With the Y arrangement of connection, it will be understood, each transformer is wound for 58 per cent. of the voltage of the circuit. Two spare transformers are installed, and the switching arrangement is such that one of the spare ones can be cut in to replace any of the three in use without shutting down. The second spare one can be connected on any phase by shutting down about one minute.

Three banks of lightning arresters are installed on the line—one at Spokane, one at the end of the line and one about 20 miles from the end of the line.

The main line is 98 miles long at the farthest sub-station and has three short branches at present. Low-tension current is transmitted about 2 miles up the cañon, making the total transmission just 100 miles.

On leaving the power house, the line goes through the city streets for 3½ miles, the poles used being from 40 to 85 feet long, in order to get above everything that might be interfered with. Whenever it crosses other lines, grounded wires are strung over the latter several feet below the transmission line.

Leaving the city, the line follows a country road for about 24.5 miles, till it reaches the Cœur d'Alene Indian reservation. Across this, a distance of 24.8 miles, almost wholly in heavy timber, a private right of way was obtained and cleared of all trees and brush. All trees outside the right of way, and liable in falling to reach the line, were also felled. At one point in this portion the line crosses the St. Joseph River at the point at which the river empties into the Cœur d'Alene Lake. The river runs close to a bluff on the west, while on the east side there is a marsh and the neck of an inlet.

At high water several feet of water stands from bluff to bluff. To span this would require 3300 feet, so set-

THE LOWER FALLS AND THE POWER HOUSE AT SPOKANE, WASHINGTON. THE AVAILABLE HEAD IS ABOUT 70 FEET, MAKING 4000 H. P. AVAILABLE
COMPRESSORS, THOUGH THERE ARE OTHER

ting the poles on a cluster of five piles was resorted to. The center one was driven about 6 feet lower than the others, and a socket was formed in which the pole was firmly clamped with heavy iron bands. By this means the longest span across the river channel was reduced to 474 feet, the wires being far above the smokestacks of the steamers that navigate the river. Number 0 B. & S. hard-drawn copper wire was used here for further security against a wire breaking. A row of single piles with a plank walk was placed across the marsh under the line, for patrolling purposes. Thus far this construction has proved most satisfactory.

Leaving the reservation, the line follows up the valley of the Cœur d'Alene River and its south fork to the mining region. It is largely on private right of way, but follows country roads in part, and goes through swamps and meadows — sometimes several feet under water—timber-covered mountains, steep rocky mountain sides and around rocky cliffs. As far as possible, it was considered best to avoid proximity to towns, railroad tracks and the like, where the youth with a 22-calibre rifle likes to walk and practice shooting, for the insulators offer a tempting target to those of a mischievous nature.

The poles of the present line are set 35 feet from the north or westerly side of the 100-foot right of way, leaving room for a duplicate line on the other side.

The standard pole is 35 feet long, of winter-cut cedar, 12 inches in diameter at the ground line and 8 inches at the top. They are set 6 feet in the ground. Special lengths are used in hollows, at the bottom of ravines and the like, to avoid making too great a change in the slope of the wires on any one insulator, and also at railroad crossings and in villages.

The wires are of No. 2 B. & S., medium, hard-drawn copper, and are placed to form an equilateral triangle 42 inches on a side. The upper insulator is set on the top of the pole, the others at both ends of the cross-arm. A complete set of three partial transpositions is made in each section where the condition varies in parallel-telegraph, telephone and other lines; otherwise it is made every mile.

A private telephone line is run on the side of the poles below the power line and is transposed every few spans. The insulators used are of the double-petticoat type, 13-inch size, and are

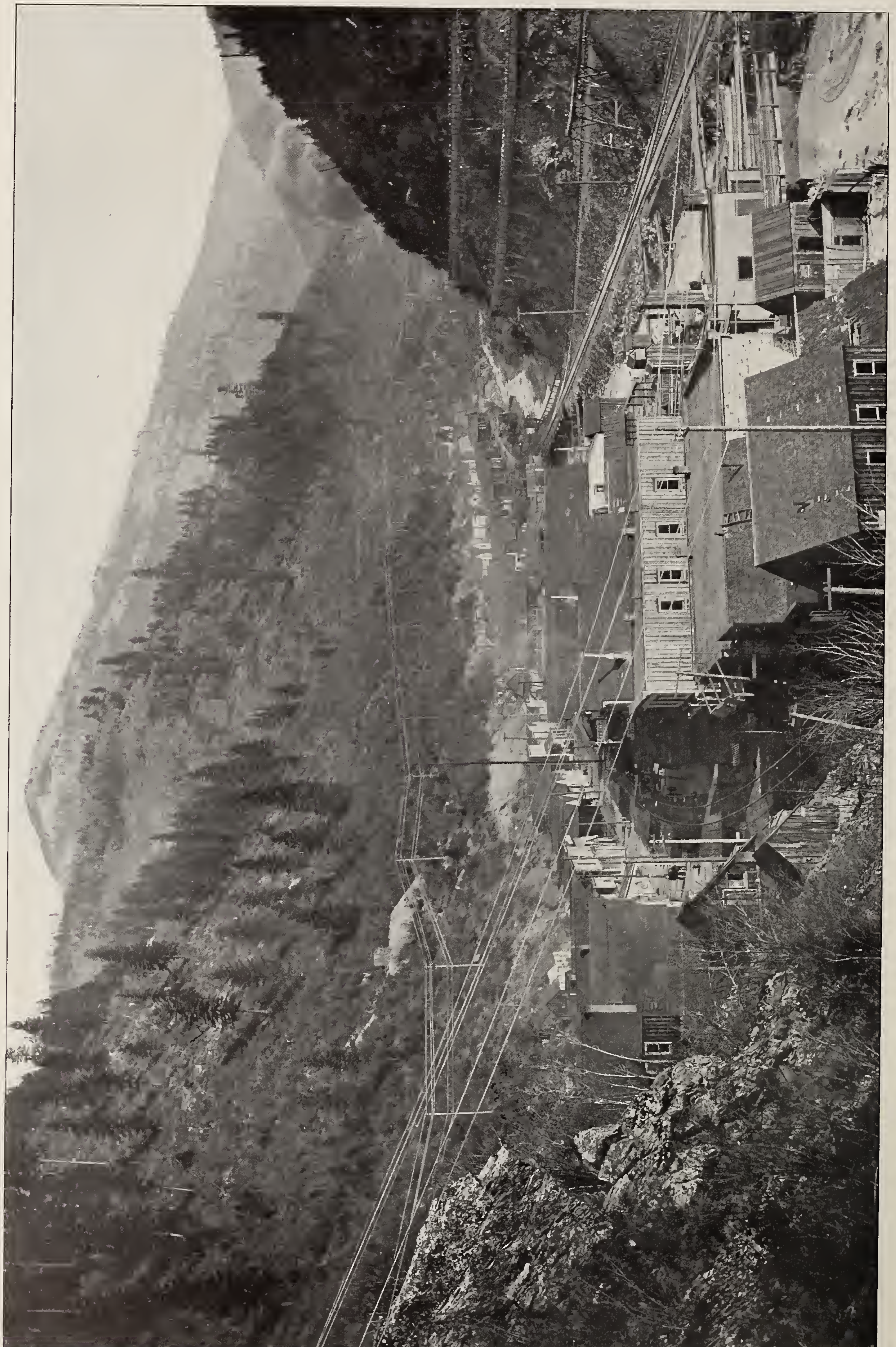
FOR TRANSMISSION TO THE COEUR D'ALENE MINE DISTRICT. THE POWER IS EMPLOYED PRINCIPALLY FOR OPERATING MINE HOISTS AND AIR MINOR USES FOR IT, AS TOLD IN THE ARTICLE

mounted on a metal pin. This pin is described by Mr. D. L. Huntington in the "Transactions of the American Institute of Electrical Engineers" for April, 1903, page 453, and has given entire satisfaction to date.

The sub-station buildings are of brick. The high-tension wires, entering near the top, go directly to knife-disconnecting switches, set on a gallery, and thence to the transformers on the ground floor. One transformer of the three-phase type is used. The secondary wires pass from the transformer to a switchboard, carrying oil circuit-breakers, recording wattmeters and indicating instruments, and thence to the customers' circuits. The half-voltage taps shown on the diagram are only for starting purposes for synchronous motors. There are eight of these sub-stations, six of which have been in continuous use since starting. Besides the foregoing, there is a sub-station recently built about 11 miles from Spokane, where power is taken from the transmission line and the voltage stepped down to 23,000 to supply the lines of an interurban railway 33 miles long. The railway company uses the power through rotaries to supply the trolley with 600-volt direct-current.

Several miles of long-distance telephone line parallels the transmission line at a distance of about 40 feet, and one of the telephone company's engineers was much worried, fearing trouble with the operation of these lines. Three days after the transmission was in operation, he asked when the current would be turned on, as he wished to notice how much the change was. Upon learning that the current was on, he admitted he could not detect it in the operation of the telephones. There is very little sound on the private telephone line from induction, unless one of the telephone wires becomes grounded, when it is almost impossible to understand a person talking over the telephone.

A rather peculiar loss of from 1 to 6 feet of head in the draft tubes is encountered at the ordinary height of the river. The center of the wheel-shaft is then about 18 feet above tail-water. Not far above the intake to the power house the river divides into several channels, and falls about 60 feet over numerous small dams and cascades composing the "upper falls," reaching this level a few hundred feet above the intake. There being no quiet water whatever, considerable quantities of air seem to be taken into the flumes



A VIEW OF THE TRANSMISSION LINE AT GEM, IDAHO

with the water, no doubt held there under pressure as the water flows down the flumes, to be instantly released upon passing through the wheels into the partial vacuum in the draft tubes. This, no doubt, explains a part of the loss of head.

Another peculiar phenomenon is noticed every time one of the 4000-H. P. wheels is started. Of it the writer has found no satisfactory explanation, and would be glad to hear one. The following characteristic observations were recorded by him:—The gauge pressure at the center of the wheel-shaft being noted as 24 pounds and the vacuum in draft tubes being zero, the gate of the wheel was opened slowly. Full speed was reached in about one minute, the gate being opened 9 per cent. The vacuum was noted as rising rapidly. The speed remained steady for two or three minutes and the vacuum increased to 10 inches of mercury; suddenly the wheel slowed down 20 per cent., the vacuum continuing to rise to about 13 inches of mercury, where it remained practically stationary. The wheel continued to run at steady speed —20 per cent. low—until the gate was further opened, it requiring 16 per cent. gate opening to bring the wheel back to speed. The pressure gauge showed a loss not exceeding one-tenth of a pound, while the vacuum remained about the same.

The power house being ready before the line was completed, 77 miles of line were first tested. All switches were closed and the generators started slowly from rest. The speed was gradually increased, the connections having been made for 60,000 volts pressure. The pressure was brought up to 42,000 volts and then cut down slowly to zero without any indications of trouble.

Next morning the machine was started again in the same manner, the voltage being raised to about 68,000 volts for a short time, and then lowered to about 58,000 or 60,000 volts, and held there all day while the entire line was patrolled and was found to be in good condition. Along the line a discharge could be heard at a large percentage of the insulators. With 58,000 volts on the line, the amperes shown on the generator were 230 in each leg, while the wattmeter indicated 25 kilowatts per leg. This would show the charging current to be approximately 15 amperes, while, after the step-up transformer loss was deducted, the remaining energy lost in the line would not be over 10 K. W. per wire, or a total of less than 30 K. W.

In this test only one set of lightning arresters was connected, that being at Spokane; each division of the set was composed of 24 General Electric 2000-volt, double-pole arresters connected in series, thus forming 96 spark-gaps from each wire to the ground. A steady stream of sparks could be noticed through the first few air-gaps. These became less frequent as the number of gaps crossed became greater, and before reaching half-way down the arresters the sparks were no longer visible.

The leading current exerted such an exciting effect on the generator that the exciter voltage had to be reduced to 85 volts and all the generator fields resistance cut in, giving an exciting current of about 50 amperes, whereas, with the generator half-loaded with non-inductive load, the exciter was run at 115 volts with the generator rheostat handle in about central position.

After this test the line was shut down for four days, the transformers were connected for 45,000 volts line pressure, and the first sub-station, 79 miles from Spokane, was cut in. The voltage was brought up to 43,000 volts, and simultaneous volt readings were taken by means of telephone, the voltage being very steady. The voltage indicated at the sub-station was a little over 44,000. The voltmeters were new, but were not compared; however, the error ought not to have been 2 per cent. The amperemeters in Spokane on the 4000-volt side of the transformers indicated 120 amperes, giving about 10.5 amperes for charging current at this voltage, there having been 2 more miles of line and an unloaded transformer and bank of lightning arresters at the sub-station cut in since the test at 58,000 volts.

During the first test the neutral wire was not grounded at the power house, and the floating around of the neutral point was plainly noticed on the lightning arresters, the sets connected to the three wires showing considerable difference, sometimes one being most active and then another. Grounding the neutral wire stopped the greater part of this effect, although a slight varying difference still seemed to exist.

As induction motors were started, the amperes supplied to the step-up transformers decreased until a minimum reading of about 95 amperes was

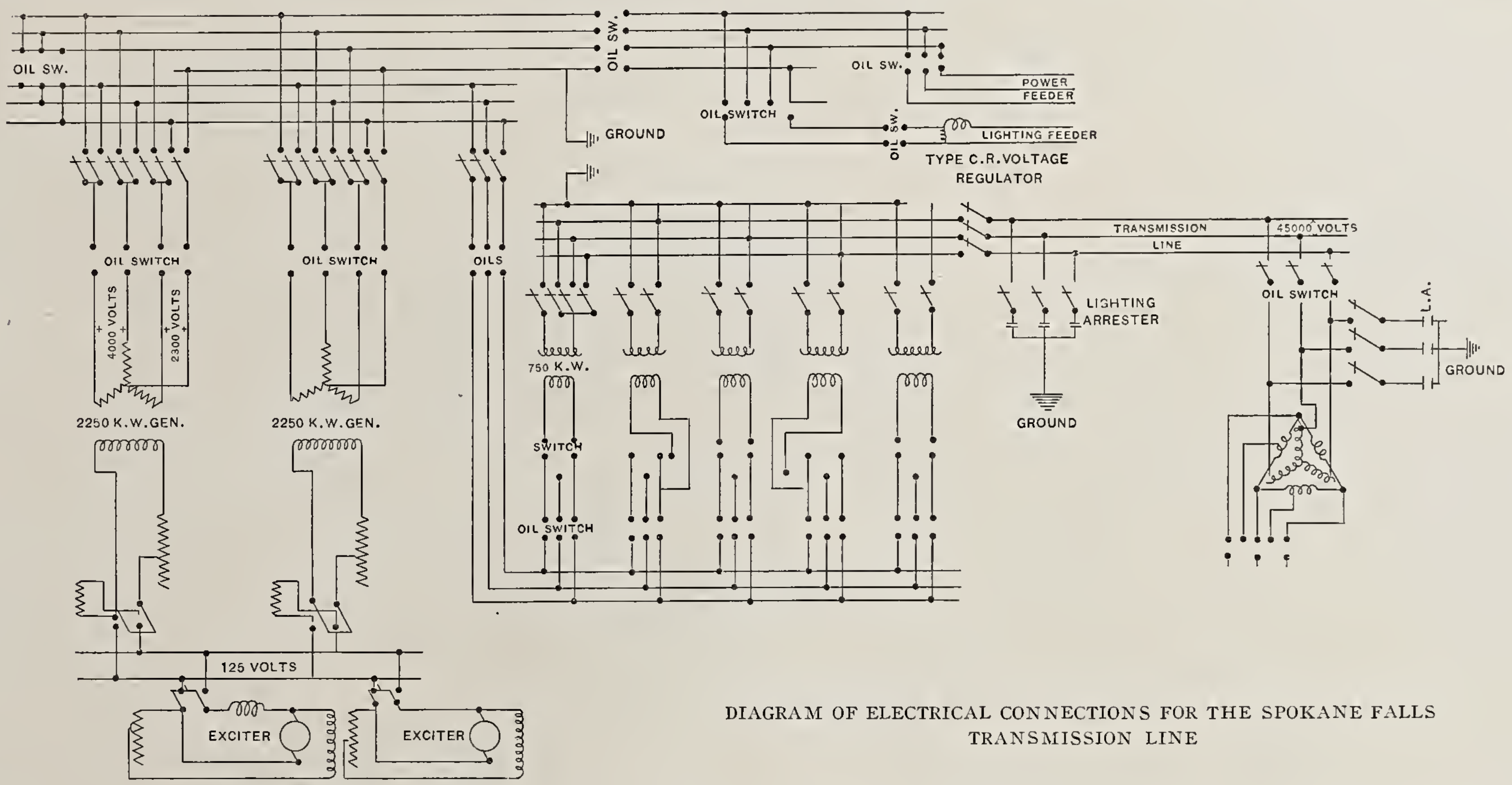


DIAGRAM OF ELECTRICAL CONNECTIONS FOR THE SPOKANE FALLS TRANSMISSION LINE

A VIEW OF THE LOWER FALLS AND POWER HOUSE AT SPOKANE

reached. The kilowatts were not observed, owing to the generator furnishing current to the city as well at this time, and the proportion of the total supplied to the city and the line could not be accurately obtained. After this time, adding more load increased the current; accordingly the minimum current is about 8 1-3 amperes for 79 miles of the line at 43,000 volts.

The work was rapidly pushed to completion and the sub-stations were put in operation, each sub-station being put into service as soon as the line reached it. The power was cut off only long enough to make connections to each piece of new line. Accordingly there was no opportunity to test the charging current and the kilowatts of the complete line, for one could never be sure that the whole of the load was off at the various sub-stations. From two of these current is supplied for lighting purposes, the towns of Wardner and Kellogg being lighted from one.

At the time of writing, unity power factor is usually reached with a load of 1450 K. W. The current in the line is then about 18.5 amperes per wire. Four 300-H. P. induction motors, one 240-H. P. synchronous motor and several induction motors of smaller sizes are in operation on the line. One of the 300-H. P. induction motors is supplied from the sub-station at the end of the line, and is direct-connected to a hoist which is in almost constant use. During the first two months the motor had to be run entirely unbalanced, the effect of this hoist upon the regulation of the line being at first very serious.

The motor is a three-phase General Electric, built for 514 revolutions per minute, 2080 volts and 60 cycles. When the load on the line was light and this motor was started, it threw a heavy inductive current on the line, increasing the power factor instantly, leaving the generator much under-excited, and causing the voltage to drop. To this had to be added a drop of about 1 or 1½ per cent., owing to drop in speed. The speed was about recovered when the load came off again, restoring the power factor and excitation to the generator, while the speed rose about as much as it fell on starting the motor, causing the voltage to go slightly above normal.

Ordinarily, the voltage at Spokane fell about 10 or 12 per cent. and rose 2 per cent. from normal, while extreme cases were nearly twice as bad. The voltage at the end of the line varied in general about 1.6 times as much as it did at the power house. This action continuing every two or three minutes, needless to say, made the power unsatisfactory for lighting purposes, while the speed variation of the induction motors was enough to bring forth severe complaint where they were used to run milling machinery requiring a very constant speed.

Even the 240-H. P. synchronous motor, mentioned in the foregoing, judging from the attendant's account, started to fall out of step, slipped over a few poles, and again got in step, though causing much anxiety. After a day or two of this, a man was put in

constant attendance on the generator rheostat, and the writer went to the end of the line to study conditions and see what could be done. He found that the motor as then handled took about 275 kilovolt amperes for the first point on the controller. The operator then moved the handle rapidly, bringing the kilovolt amperes up to 400 or 450, made the run and shut off quickly. The time of raising a car from the 300-foot level was twenty-five seconds, and from the 600-foot level was forty-five seconds. It was noted by comparing recording voltmeter charts that the attendant at the switchboard in Spokane could do little to keep the voltage from falling, but could bring it back very quickly.

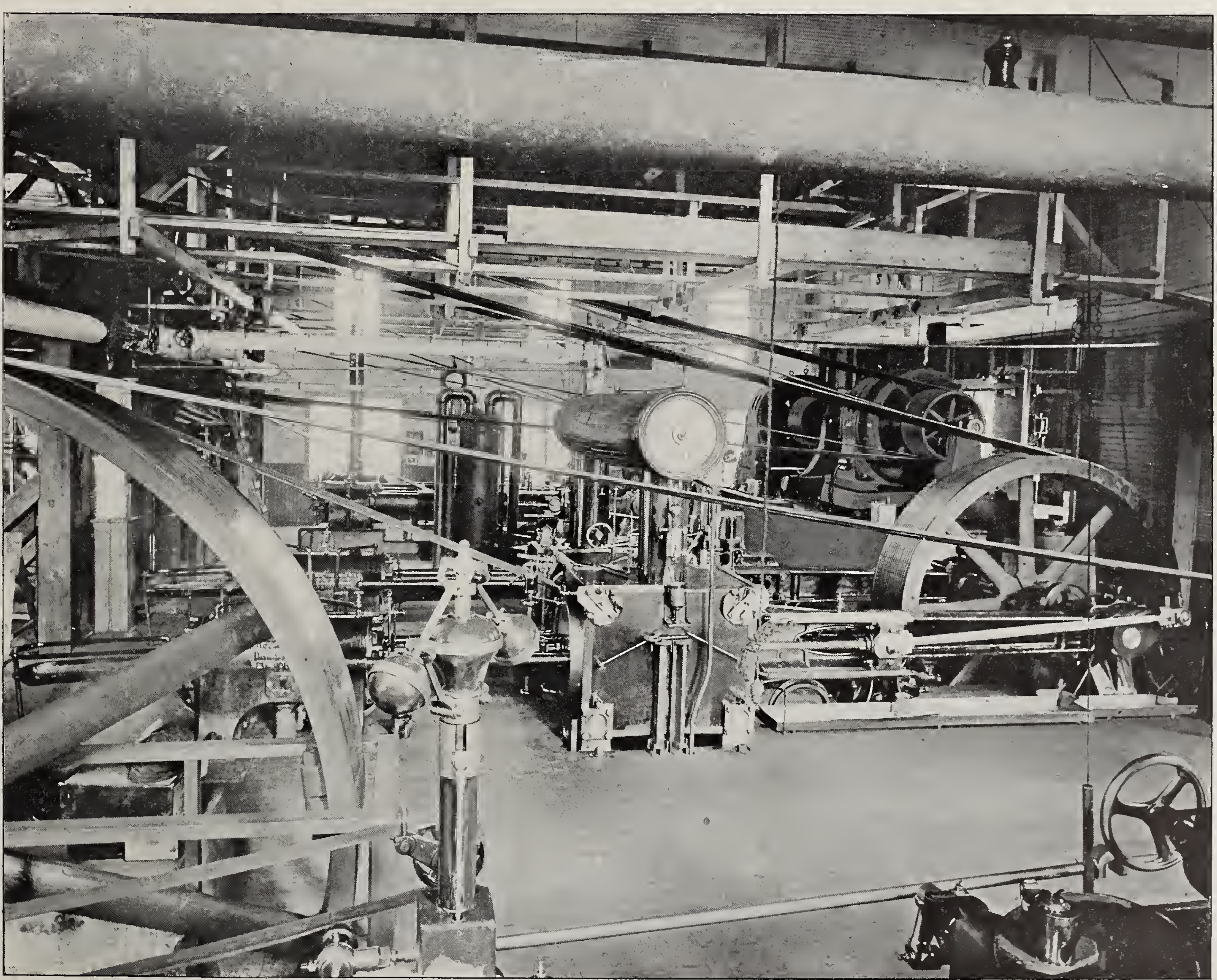
When the motor was cut out the voltage rose nearly as much as it dropped before. However, the general effect was much improved. It was found that the controlling rheostat of the motor was too small to stand regulating the speed of the motor for any considerable time, so, as a temporary makeshift, a resistance was made of iron wire and inserted in the circuit between the starting box and the rotor. This had the effect of cutting down the kilovolt amperes taken at the first point to about 175, and the operator could then move the controller handle more slowly.

The first instantaneous drop in voltage was much reduced, and the attendant at the power house had a chance to hold the voltage nearer normal.

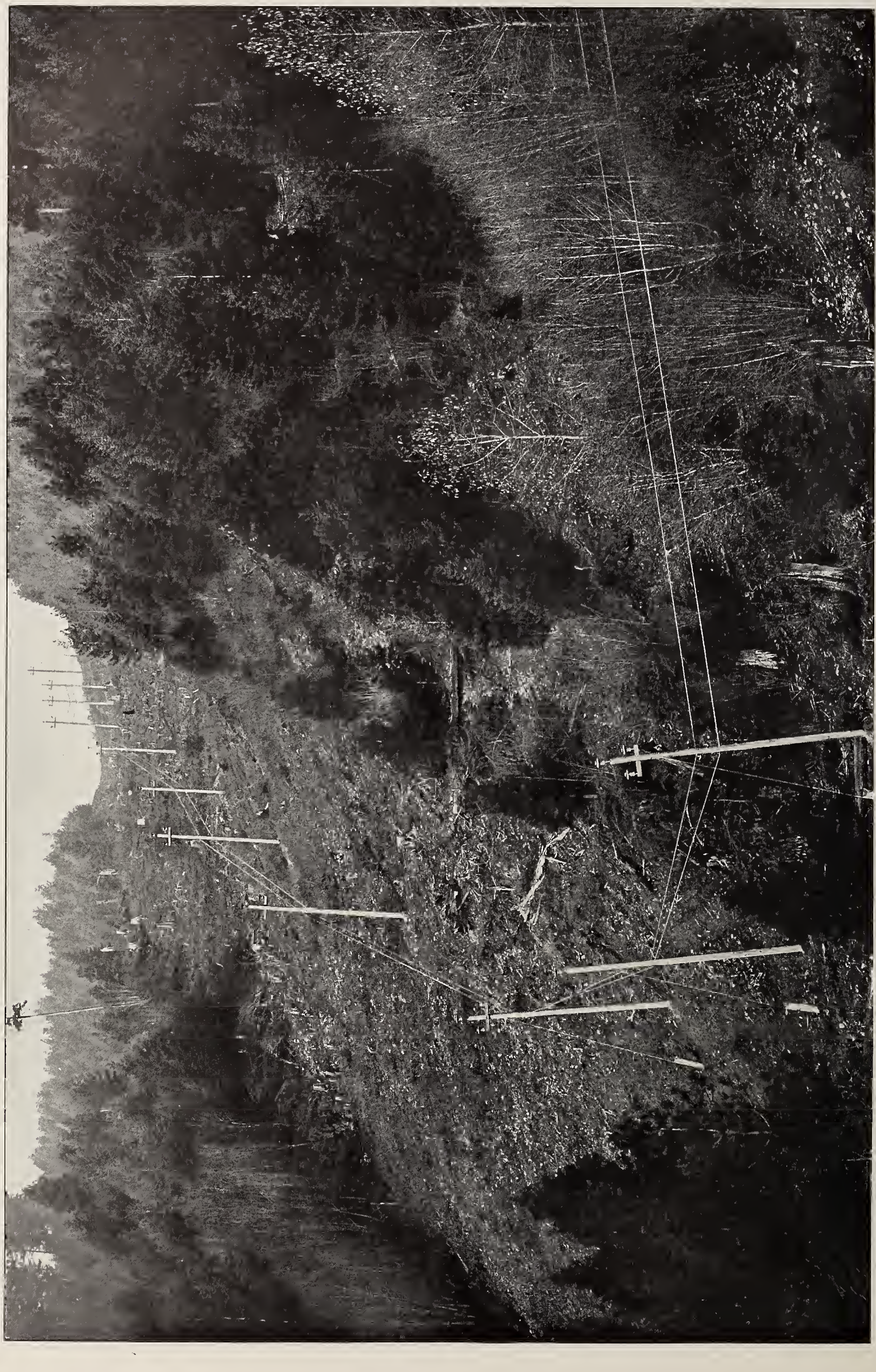
With this condition the voltage usually fell at the power house about 6 or 7 per cent., and rose nearly as much above normal. While this gave rather poor lighting service, it did not seriously interfere with the motors. This arrangement, however, has the bad feature of running the motor at a slower speed and so doing only the work of a small motor. This is not serious while operating from shallow shafts, but would be unsatisfactory for deeper workings in the future.

The writer accordingly recommends for such requirements a rheostat large enough not to overheat when running with any part of it in use, the first point giving a current nearly as small as that taken by the motor with the rotor open-circuited. The second point would increase the current about 30 per cent., the next 30 more, the remaining ones giving more gradual changes. The motor would not start until the third, or if heavily loaded, perhaps the fifth, point. The controller handle also ought to have a time relay device, making it necessary to consume about three seconds between the first and second points, two between the second and third, and one for the next, and also a smaller time limit for cutting out these points.

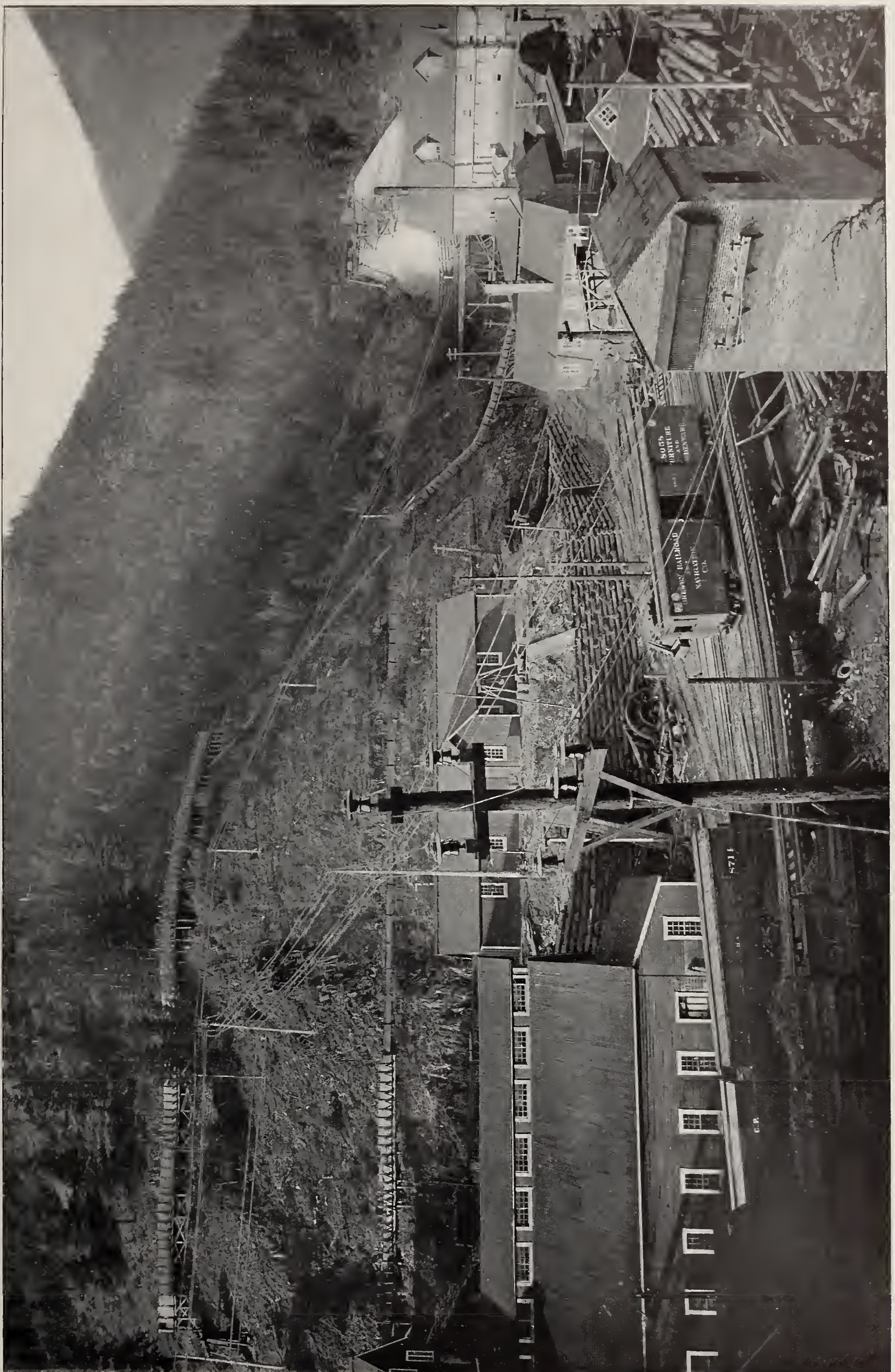
An emergency switch ought to be provided, so that the operator could cut off the current instantly, if necessary. This would enable the power house to care for the small changes and keep the voltage near its standard



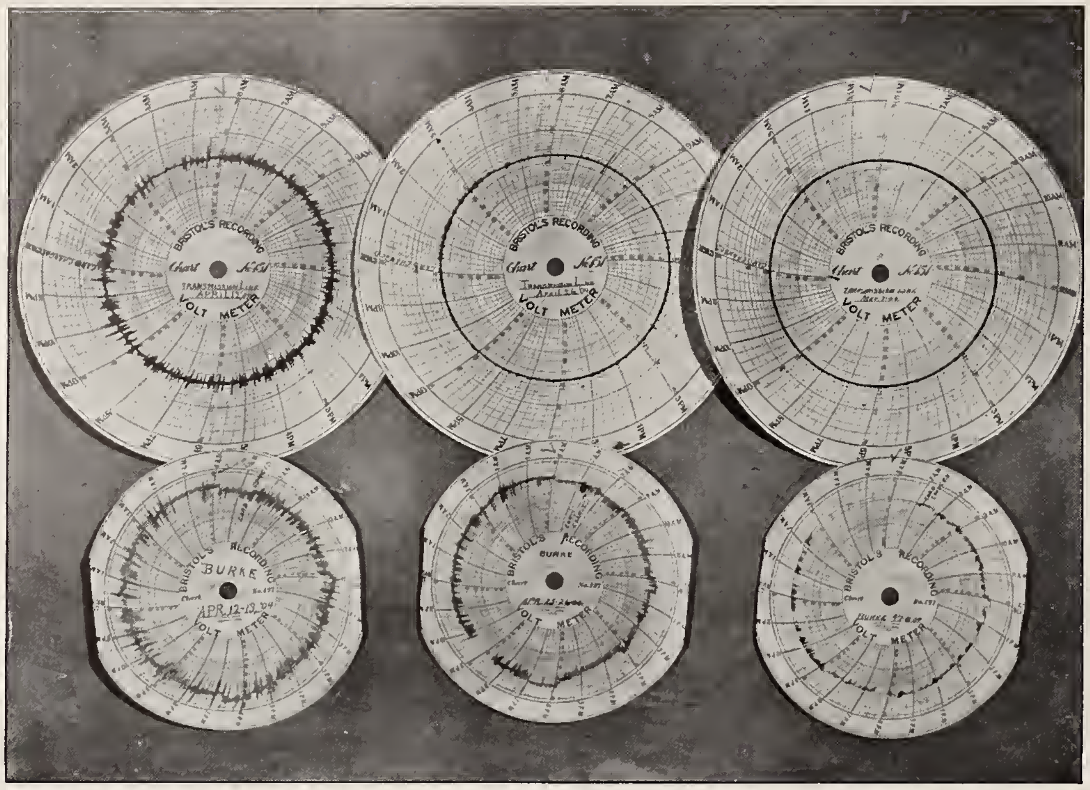
TWO OF THE 300-H. P. INDUCTION MOTORS WHICH HAVE DISPLACED STEAM ENGINES



A SHARP TURN IN THE TRANSMISSION LINE



THE END OF THE TRANSMISSION LINE AT THE BURKE STEP-DOWN TRANSFORMER STATION, IDAHO



A STUDY IN VOLTAGE REGULATION

there, the line loss being the principal thing left to contend with.

A large water rheostat was installed at Spokane and used in connection with the transmission line, and was found to be of use on light loads; but when the power factor reached 100 per cent. it did little good and could be cut out.

The voltage regulator for the power house and a larger controlling resistance for the hoist motor have been installed since this paper was first written. The illustration of charts on this page shows the effect upon voltage regulation. Those in the upper row were taken at the power house, while those below are the corresponding charts taken at the end of the line. There is an hour's difference in time, that at the end of the line being one hour before that at Spokane. The charts are changed at different hours.

Those on the left are average charts after the temporary resistance had been installed at the hoist mentioned in the foregoing, and with constant attendance at the generator rheostat. The author regrets that he has no representative charts of the condition before making the temporary change. The charts in the center show the voltage under the same conditions after installing the voltage regulator. Those on the right show what was obtained after the new controlling resistance was installed on the motor.

A suggestion was made to install a large synchronous motor at the end of the line, with no load except its own exciter, and install one of these regulators to operate on the field of this motor. If the line voltage drop, the regulator should strengthen the motor field and throw a leading current on the line. If the voltage rose, the field should be weakened to throw a lagging current on the line. The objection to using a motor installed for other purposes is that the motor would often be shut down, and would be largely out of the power company's control.

It may be of interest to note that while the line has been in continuous operation for over seven months, the circuit-breaker has been tripped only eight times, except when arrangement for a short shut down has been made with all the parties interested Of these eight trippings, two were caused by accidental short-circuits on the line, made by the company's workmen; four were short-circuits on the secondaries of customers, and were severe enough to throw out the secondary breaker, the sub-station breaker and the power house breaker all at once; the other two were from unknown causes. The total time the power has been off because of these troubles is thirty-two minutes.

According to Sir Oliver Lodge in "Harper's Magazine," electricity is not a form of energy any more than water is a form of energy. Water may be a vehicle of energy when at a high level or in motion; so may electricity. Electricity cannot be manufactured, as heat can; it can only be moved from place to place, like water; and its energy must be in the form of motion or of strain. Electricity under strain constitutes "charge"; electricity in locomotion constitutes a current and magnetism; electricity in vibration constitutes light.

Transatlantic Wireless Telegraphy

NEARLY every writer on wireless telegraphy from its inception, says "Cassier's Magazine," has called attention to the fact that the term wireless as applied to electric wave telegraphy is a misnomer, inasmuch as wires are still somewhat extensively used in its operation; but it remained for a more recent, and evidently a cynical, writer to assert that the term telegraphy, as applied to this system, was also a misnomer, because he had known cases where two ships had tried for an hour to say to one another that they had nothing to say.

This, however, is rather a severe fling at wireless telegraphy, for while the art has well-defined limitations and is not yet by any means perfected in all of its details, it has nevertheless reached a point when it can truly be said to be of much practical utility in places where wire telegraphy cannot well be employed. Perhaps the greatest error that has been made in the past by the foremost worker in wireless telegraphy has been in attempting to obtain results beyond the utmost present capacity of the apparatus; in other words, time has been wasted in trying to make the child walk before it can creep. And this appears to be an error from which it is difficult for some people to depart, for, nothwithstanding that the elaborate efforts of the past four or five years to bring about successfully transatlantic wireless telegraphy have, up to the present time, seemingly failed, it is now stated that work in this particular direction must be delayed pending the making of arrangements for opening up wireless communication between Italy and South America, a distance of 6400 miles.

The inutility of this method of procedure may be better understood when it is considered that the wave energy emitted by the wireles transmitter decreases at least as the square of the distance, from which it is easy to calculate that the chances of successful wireless transmission between Italy and the Argentine Republic are four times less than between Europe and North America. In the meantime, however, it is interesting to know that the Italian Government has fixed the rate for wireless messages between Italy and South America at 4d. per word, which is so much done.

The New England Cotton Manufacturers' Association will hold its seventy-seventh meeting on Wednesday and Thursday, September 21 and 22, at the Mount Washington Hotel, Bretton Woods R. R. Station, N. H.

Electric Transmission Lines

Line Wire Materials and High Voltages

By ALTON D. ADAMS

COPPER, aluminium, iron, and bronze all are used for conductors in long-distance electric transmissions, but copper is the standard metal for the purpose. A conductor for transmission lines should combine the best electrical conductivity, great tensile strength, a high melting point, low coefficient of expansion, hardness, and great resistance to oxidation. No one of the metals named possesses all of these properties in the highest degree, and the problem is to select the material best suited to each case. Aluminium suffers very slightly by exposure to the weather; copper and bronze suffer a little more, while iron and steel wire are attacked seriously by rust.

Iron, copper and bronze are all so hard that little or no trouble has occurred from wires of these metals cutting or wearing away at the points of attachment to insulators. Aluminium, on the other hand, is so soft, that swaying of the wire may, in time, cause material wear at the supports, or it may be cut by tie wires. But lines of aluminium wire have not been in use long enough to determine how much trouble is to be expected from its lack of hardness.

A small coefficient of expansion is desirable in transmission wires, because the strain on the wire itself and on its supports varies rapidly with the amount of vertical deflection of each span, becoming greater as the deflection decreases. Only a moderate amount of deflection is desirable because of the opportunity it gives for swaying of the wires. If the material used has a large coefficient of expansion the wires show too much deflection in hot and too little in cold weather. Taking the expansion of copper as unity, that of aluminium is 1.4; of bronze, 1.1; and of iron and steel, 0.7. From these figures it follows that iron and steel wires show the least variation in the amount of sag between supports, and aluminium wire shows the most.

Wrought iron melts at about 2800 degs., steel at 2700, copper at 1929, bronze at about the same point as copper, and aluminium at 1157 degrees F. This low melting point of aluminium may prove a source of trouble by opening a line of that material where some foreign wire falls on it. This, according to a report, was illustrated at a sub-station on a 30,000-volt transmission line where a destructive arc was started at the switchboard. Not being able to extinguish the arc in any other way, a lineman threw an iron wire across the aluminium lines just outside of the sub-station, and these lines were immediately melted through by the iron wire, thus opening the circuit. The trouble may have warranted so desperate a remedy in this case; but, as a rule, it does not pay to cut a transmission line in order to get rid of a short circuit.

In the ordinary construction of transmission lines on land the tensile strength of wire is secondary in importance to its electrical conductivity, because supports can be spaced according to the strength of the conductor used. When large bodies of water must be crossed, tensile strength is a prime requirement. Thus a 142-mile line from Colgate to Oakland, in California, crosses the Straits of Carquinez in the form of four steel cables, each $\frac{7}{8}$ inch in diameter and 4427 feet long. Steel wire was selected for this long span, probably because it can be given a greater tensile strength than that of any other metal. Annealed iron wire has a tensile strength between 50,000 and 60,000 pounds per square inch. Steel wires vary all the way from 50,000 to more than 350,000 pounds per square inch in strength, but mild steel wire with a strength ranging from 80,000 to 100,000 pounds per square inch is readily obtained.

Soft copper shows a tensile strength between 32,000 and 36,000 pounds per square inch, and hard-drawn copper, between 45,000 and 70,000 pounds, depending on the degree of hardness. Silicon-bronze wires vary in strength from less than 60,000 to more than 100,000 pounds per square inch, and phosphor-bronze has a tensile strength of about 100,000 pounds. Bronze wires, like those of most alloys, show a wider range of strength than those of iron or copper.

In silicon-bronze wire the electrical conductivity decreases as the tensile strength increases. The tensile strength of aluminium wire is lower than that of any other used in transmission lines, being only about 30,000 pounds per square inch. Solid aluminium wires of large size have given trouble by breaking under strains well within their nominal strength, due probably to imperfectness or twists. This trouble is now generally avoided by the use of aluminium cables.

In that most necessary property of a transmission line,—conductivity,—copper excels all other metals, except silver. Taking the conductivity of soft copper wire at 100, the conductivity of hard-drawn copper is 98; that of silicon-bronze ranges from 46 to 98; that of aluminium is 60; of phosphor-bronze, 26; of annealed iron wire, 14; and of steel wire of 100,000 pounds tensile strength per square inch, 11. Copper wire, both soft and hard, as regularly made, does not vary more than 1 per cent. from the standard, and aluminium and annealed iron wires also show high uniformity as to resistance. Silicon-bronze and steel wires, on the other hand, fluctuate much in electrical conductivity. For any particular transmission line the resistance is usually determined by considerations apart from the metal to be used as a conductor, so that a line of given resistance or conductivity must be constructed of that material which best conforms to the requirements as to size of wire, weight, strength, and cost.

Allowing the weight of any definite mass of copper to represent unity, the weight of an equal mass of wrought iron is 0.87; of steel, 0.89; of aluminium, 0.30; while that of bronze is very nearly equal to that of copper. The smallest line wire that can be used for a given length and resistance is one of pure, soft copper. Next in cross-sectional area come hard-drawn copper and some silicon-bronze, either of which need be only 2 per cent. larger than the soft copper for an equal resistance. Some other silicon-bronze wire of greater tensile strength per

square inch would require a sectional area 2.17 times that of the soft copper.

Aluminium wire with 60 per cent. of the conductivity of copper requires 1.66 of its section for wires of equal resistance. As phosphor-bronze has only 26 per cent. of the conductivity of copper, the section of the bronze must be 3.84 times that of the copper wire if their lengths and resistances are to be equal. An annealed iron wire is equal in resistance to a copper wire of the same length when the iron has 7.14 times the section of the copper. Steel, with 11 per cent. of the conductivity of copper, must have 9.09 times the copper section in order that wires of the same length may have equal resistances.

It is not desirable to use a copper wire smaller than No. 4 B. & S. gauge for transmission lines, because of the lack of tensile strength in smaller sizes. When the conductivity of a copper wire smaller than No. 4 is ample, an iron wire will give the required conductivity, with a strength far greater than that of the copper. For a line of given length and conductivity of any other metal the weight compared with that of a copper line is represented by the product of the figures for relative section of the two lines and of the weight of unit mass of the metal in question compared with that of copper.

Thus, for the same conductivity the weight of a certain length of iron wire is $0.87 \times 7.14 = 6.21$ times the weight of a copper wire. For the steel wire above named the weight is $0.89 \times 9.09 = 8.09$ times that of a copper line of equal conductivity. Phosphor-bronze in a line of given length and resistance has 3.84 times the weight of soft copper. Silicon-bronze for a transmission line must weigh from 1.02 to 2.17 times as much as soft copper for a given length and conductivity. Aluminium for a line of fixed length and conductivity will weigh $1.66 \times 0.3 = 0.5$ times as much as copper. For a line of fixed length and resistance, hard-drawn copper will weigh about 2 per cent. more than soft copper.

Taking the tensile strength of soft copper at 34,000 pounds per square inch; hard-drawn copper, 45,000 to 70,000; silicon-bronze, 60,000 to 100,000; phosphor-bronze, 100,000; iron, 55,000; steel, 100,000; and aluminium at 30,000 pounds, the relative strengths of wires with equal sectional areas compared with the soft copper are, for hard-drawn copper, 1.32 to 2.06; silicon-bronze, 1.76 to 2.94; phosphor-bronze, 2.94; iron, 1.62; steel, 2.94; and for aluminium, 0.88.

Comparing wires on the basis of equal resistances for equal lengths, with soft copper again the standard, the tensile strength of each as to it, is as follows:—A hard-drawn copper line has $1.02 \times 1.32 = 1.34$ to $1.02 \times 2.06 = 2.10$ times the strength of a line of soft copper. With silicon-bronze the strength of line wire would range between $1.02 \times 1.76 = 1.79$ and $2.17 \times 2.94 = 6.38$ times that of copper. Iron would give the line a strength as to soft copper represented by $7.14 \times 1.62 = 11.56$. Steel of 100,000 pounds tensile strength per square inch will give a line $9.09 \times 2.94 = 26.70$ times as strong as it would be if composed of soft copper. With aluminium the strength of the line would be $1.66 \times 0.88 = 1.46$ times that of copper. For phosphor-bronze the figures are $3.84 \times 2.94 = 11.29$.

From the foregoing it may be shown how many times the price of soft copper per pound may be paid for each of the other metals to form a line of given length and resistance at a cost equal to that of a soft copper line. These prices per pound for the several metals relative to that of soft copper are as follows:—Taking the price of soft copper as 1, the price for hard-drawn copper must be $1 \div 1.02 = 0.98$. For silicon-bronze the price may be as high as $1 \div 1.02 = 0.98$, or as low as $1 \div 2.17 = 0.46$ of the price of soft copper wire. Phosphor-bronze may have a price represented by only $1 \div 3.84 = 0.26$ that of copper. The price of iron wire should be $1 \div 6.21 = 0.16$ of that of copper, and for steel wire of the quality stated the price can only be $1 \div 8.01 = 0.12$. Aluminium wire alone may have a higher price per pound than soft copper for the same resistance and cost of line, the figure for the relative cost of this metal being $1 \div 0.5 = 2$.

From the foregoing it appears that for a line of given cost, length, and resistance, soft copper has the least cross section and tensile strength; steel, the greatest cross section, weight, tensile strength and lowest permissible price per pound; and aluminium, the least weight and highest price per pound.

RELATIVE PROPERTIES OF WIRES HAVING EQUAL LENGTHS AND RESISTANCES

Metal in Wire	Relative Cross Sections	Relative Weights	Relative Tensile Strengths	Relative Prices per Pound for Same Total Cost
Soft copper	1.00	1.00	1.00	1.00
Hard copper	1.02	1.04	1.34	0.98
Very hard copper	1.02	1.02	2.10	0.98
No. 1 silicon bronze	1.02	1.02	1.79	0.98
No. 2 silicon bronze	2.17	2.17	6.38	0.46
Aluminium	1.66	0.50	1.46	2.00
Phosphor bronze	3.84	3.84	11.29	0.26
Annealed iron	7.14	6.21	11.56	0.16
Mild steel	9.09	8.09	26.70	0.12

The relative cross-sections and weights of both iron and steel wires are so great as to prevent their general use, because of the resulting labor of their erection and large cost of supports.

So far as the first cost of the wire alone is concerned, iron may be approximately equal to copper in some metal markets. The only practical place for an iron wire, however, is one where copper would be too small or not strong enough. Steel wire finds a place, in spite of its high resistance, in those exceptional cases where a single span of several thousand feet must be made, requiring high tensile strength. In such cases it is usually better to give the steel span a greater resistance than an equal length of the main portion of the line, so as to avoid excessive size and weight of the span. Even when this is done the resistance of the steel span would be very small compared with that of a long transmission line.

Phosphor-bronze finds little use as conductors in transmission systems, because of its relatively high electrical resistance. If great tensile strength is wanted, iron or steel will supply it at a fraction of the cost of the phosphor-bronze. As a conductor simply phosphor-bronze is worth only 0.26 as much per pound as soft copper, while its actual market price is greater than that of copper.

Silicon-bronze, of relatively high resistance, requiring 2.17 times the section and weight of copper for equal conductivity, is entitled to little or no consideration as a transmission line material. This alloy, in order to give equal conductivity at equal cost with copper, must sell at only 0.46 of the price of copper per pound. But the price of silicon-bronze is equal to, or greater than, the price of copper, so that the cost of the high-resistance silicon-bronze for a line of given resistance will be more than twice that of copper. For this more than double cost, the bronze gives 6.38 times the tensile strength of a soft copper line of equal conductivity.

Taking the market price of steel at one-fifth that of copper, which is amply high for the steel, as a rule, a steel wire of equal conductivity with the copper will cost only 1.6 times as much and will have 26.7 times the tensile strength of the copper, or four times the tensile strength of a wire of equal conductivity made from high-resistance silicon-bronze. From this it is clear that steel offers a cheaper combination of conductivity and strength than does silicon-bronze of high resistance. That grade of silicon-bronze having the lowest resistance may cost 0.98 as much per pound as soft copper, and will have 1.79 times the strength of the copper

for equal conductivity. This bronze actually costs more per pound than copper, so that it cannot give equal conductivity at equal cost.

Very hard-drawn copper has a conductivity equal to that of the best silicon-bronze, and the tensile strength of this copper is 17 per cent. greater than that of the bronze. Silicon-bronze costs more per pound than hard copper, but even with equal prices the hard copper gives equal conductivity and higher strength at the same cost. Furthermore, the conductivity of silicon-bronze is much more liable to serious variations than that of hard copper. Between hard-drawn copper and steel there is very little apparent place for any grade of bronze in electric transmission lines.

The hardest copper wire is very stiff, and is more liable to crack when twisted or bent than is wire of only medium hardness. Such medium-hard copper has a tensile strength 34 per cent. greater than soft copper of equal conductivity, and is much used on long transmission lines. Aluminium is the one metal which, for given conductivity in a transmission line, combines a smaller weight, a greater tensile strength, and a higher permissible price than soft copper for the same total cost. For equal conductivity an aluminium wire has a greater tensile strength than one of medium-hard copper, and costs less than copper of any grade when the price per pound of the aluminium is less than twice that of copper, which is usually the case.

These properties make aluminium by far the most important competitor of copper in electric transmission and have led to its use in a number of cases, notably for the two longest lines in the world, namely, between Colgate and Oakland and between Electra and Mission San Jose, all in California.

It has not been found practicable to solder joints in aluminium wire because of the resulting electrolytic action when aluminium is in contact with other metals. Joints of aluminium wires are usually made by slipping the ends past each other in an oval aluminium sleeve and then giving the sleeve and wires two or three complete twists, or by a process of cold welding with a sleeve joint.

Long transmission lines are in nearly all cases run with bare wire supported by poles. Where very high voltages are employed no insulation that can be put on the wire will make it safe to handle, and the cost of such insulation would add materially to that of the entire line. It is, therefore, the practice to run transmission lines above all other wires and to rely entirely on the supports for insulation.

Where it is absolutely necessary to run a transmission line for some distance underground or under water, the voltage, if very high, should be reduced for that portion. The greatest voltage that it is practicable to carry on a submarine cable is not certainly known, but 3000 to 10,000 volts have been used in some cases, and in one instance at least a cable carrying alternating current at 13,200 volts has been laid for nearly a mile under water.

The considerations thus far noted apply alike to wires carrying continuous and alternating currents; but there are some other factors that apply solely to alternating lines. Owing to the inductive effects of alternating currents in long, parallel wires, such wires should be transposed between their supports at frequent intervals. The induction between wires increases with the frequency of the current carried and decreases with the distance between the wires. According to these conditions, wires should be transposed as often as every eighth of a mile in some cases, and at intervals of one mile or more in others.

An alternating current when passing along a wire tends to concentrate itself in the outer layers of the wire, leaving the center idle. This unequal current distribution increases with the frequency of the current and with the area of the cross section of the wire. The practical effect of this unequal distribution is to make the resistance of the wire a little higher for alternating than for continuous currents. In existing transmission lines the increase of resistance due to this cause seldom amounts to 1 per cent.

When an alternating current passes through a circuit, the action termed self-induction sets up an electromotive force in the circuit that opposes the flow of current, as does the resistance of the wire, and this is called the inductance of the circuit. The ratio of this inductance to the resistance of a circuit increases with the number of periods per second of the alternating current used and with the sectional area of the wires composing the circuit. For a circuit of No. 6 B. & S. gauge wire the inductance amounts to only 5 per cent. of the line resistance, but for a circuit of No. 000 wire the inductance consumes as much of the applied voltage as does the resistance.

Both the unequal distribution of alternating current over the cross section of a conductor and the inductance of circuits make it desirable to keep the diameters of transmission wires as small as other considerations permit. As soft copper has greater conductivity per unit of area than any of the other available metals, it clearly has an advantage over all of them as to inductance and increase of resistance with alternating current.

At very high voltages there is an important leakage of energy between the conductors of a circuit, and this loss varies inversely with the distance between these conductors. Thus it happens that inductance makes it desirable to bring the parallel wires of a circuit close together, while the leakage of energy from wire to wire makes it desirable to carry them far apart.

To provide greater security from interruption, the conductors for important transmissions are in some cases carried on two independent pole lines. Even where all the conductors are on a single line of poles it is general practice to divide them up into a number of comparatively small wires to decrease inductance.

Data of a number of transmission lines presented in the appended table illustrate the practice in some of the more recent and important cases as to the materials, size, number and arrangement of the wires. The sixteen plants of which particulars are given include the greatest power capacities, the longest distances and the highest voltages now involved in electrical transmissions. Each of the lines named is worked with alternat-

SIZES AND MATERIALS OF TRANSMISSION WIRES OF SOME NOTABLE AMERICAN TRANSMISSION LINES. THESE COMPRISE SOME OF THE LONGEST LINES IN THE WORLD

Location of Transmission	Line Voltage	Number Wires	Size of Each Wire B.& S. Gauge	Metal in Wire	Length of Transmission. Miles
Canon Ferry to Butte	50,000	6	0	Copper	65
Colgate to Oakland	40,000	3	00	Copper	142
		3	000	Aluminium	
Electra to Mission San Jose	40,000	3	471,034 C. M.	"	145
Santa Anna River to Los Angeles	33,000	6	1	Copper	83
Apple River to St. Paul	25,000	6	2	"	25
Welland Canal to Hamilton	22,500	3	1	"	35
		3	00	"	37
Canon City to Cripple Creek	20,000	3	3	"	23½
Madrid to Bland	20,000	6	4	"	32
White River to Dales	22,000	3	6	"	27
Ogden to Salt Lake City	16,000	6	1	"	36½
San Gabriel Canon to Los Angeles	16,000	6	5	"	23
To Victor, Colo	12,600	3	4	"	8
Niagara Falls to Buffalo	22,000	12	350,000 C. M.	"	23
Yadkin River to Salem	12,000	3	1	"	14.5
Farmington River to Hartford	10,000	3	336,420 C. M.	Aluminium	11
Wilbraham to Ludlow Mills	11,500	6	135,247 C. M.	"	4.5

ing current of two or three phase. Each three-phase line must have at least three wires, and each two-phase line usually has four wires.

On ten of the lines the number of wires is greater than three or four, thus reducing the necessary size of each wire for a given conductivity in the line. The Butte, Oakland, and Hamilton lines are run on two sets of poles for greater security, and a second pole line has been added to the Niagara and Buffalo system to carry additional wires. In the majority of cases where more than three wires have been used, the object has been to avoid inductance and other troubles incident to wires of large diameter.

The largest wire used in any of these lines is the 471,034-circular-mil cable for the 145-mile transmission between Electra and Mission San José. This cable has thirty-seven strands and is of aluminium, so that it has 1.66 times the area in cross section of a copper cable of equal conductivity. Of the two longest transmissions in the world, namely, the one of 142 miles to Oakland and the other of 145 miles to Mission San José, the former has one aluminium and one copper line, and the latter is made up of one aluminium line.

On the Niagara line, with 22,000 volts, the wires were strung 18 inches apart. The Madrid and the Hamilton lines, with 20,000 and 22,500 volts, respectively, have their wires 24 inches apart. On the Cripple Creek line the wires are 50 inches apart, and the pressure is 20,000 volts. From Colgate to Oakland the distance between the wires is only 36 inches, though the voltage is 40,000. Between Cañon Ferry and Butte the wires of the transmission line carry 50,000 volts and are 78 inches apart, showing the tendency to increase the separation of the wires at high voltages.

Electricity, the greatest competitor of gas, is employed in rather a novel manner as an aid in the manufacture and supply of gas. To increase the pressure on a pipe line some four miles from its work, a gas company in a town near Boston took a pressure blower, cut it in series with the gas main and connected an electric motor to it. This acts like a step-up transformer on an electric line to increase the gas pressure in the main, giving a high-pressure gas transmission. Another New England gas company has installed an electric power plant of some 800 K. W. to supply power for their coal hoisting and conveying apparatus and for operating various portions of the gas plant.

Lightning Statistics

SINCE 1890, according to London "Engineering," the Hungarian Government has developed a very efficient system of collecting information on lightning and the damage done by it. The statistics are compiled by the Royal Institution for Atmospheric Electricity and Earth Magnetism. The local authorities are directed to enquire into any case that comes under their notice and to report to this institution. The rural policemen have instructions to pay particular attention to the effects of lightning; and the insurance companies have to send in monthly reports on damage done by lightning. As thunder storms and hail generally go together, and as in Hungary most farmers insure against hail, a good deal of useful information is collected in this way.

According to the statistics for the ten years ending 1900, published last year by Ladislaus Szalay, on behalf of the Meteorological Institution, 601 people were killed by lightning in Hungary during the four years 1897 to 1900. Calculated on the population of 1890— fifteen million inhabitants— that would make one fatal accident a year for every 100,000 people. In the district of Szilagy there was one death for every 30,000 inhabitants. The number of fires caused by lightning was 309 per year. Referred to the number of houses in a district, the frequency of fires varied very much. We find one fire for 1200 houses in one district against one for 56,000 houses in another as extreme cases.

The statistics do not show any distinct increase in the number of accidents due to lightning within recent years, although it has often been asserted that thunderstorms had become more destructive of late. The greatest number of accidents are reported from the districts with the densest populations. That does not necessarily imply, however, that densely populated areas suffer comparatively more; for large works do not appear to be particularly endangered, and in a country like Hungary, where large tracts are very sparsely populated, we cannot yet speak definitely of the general distribution of lightning.

We read, however, that lightning is comparatively rare in large towns, and in these most frequent in the suburbs, where the houses are least crowded. About a quarter of all the recorded lightning strokes are in relation to isolated objects not situated within towns or villages. In some of the meteorological stations, Fenyi's multiple needle-point coherers are used, which do not respond to sheet lightning. In Prussia, somewhat similar statistics have recently been published for the period 1885 to 1898. From these it would appear that, although the number of lightning strokes fluctuates considerably, we can broadly distinguish between years of fiery strokes, and of cold strokes which do not cause a fire. The distinction is, of course, arbitrary.

In Berlin, so-called cold lightning strokes had not been observed at all within recent years, while they are not unknown in other large towns. During the period mentioned, lightning produced fires in towns in 2158 cases, and in the country in 13,785 cases, while 525 cold strokes were reported from towns and 1734 from the country. In the country districts, about 11 per cent. of all fires were due to lightning; in the town this proportion decreased steadily from 6.7 to 4.2 per cent.

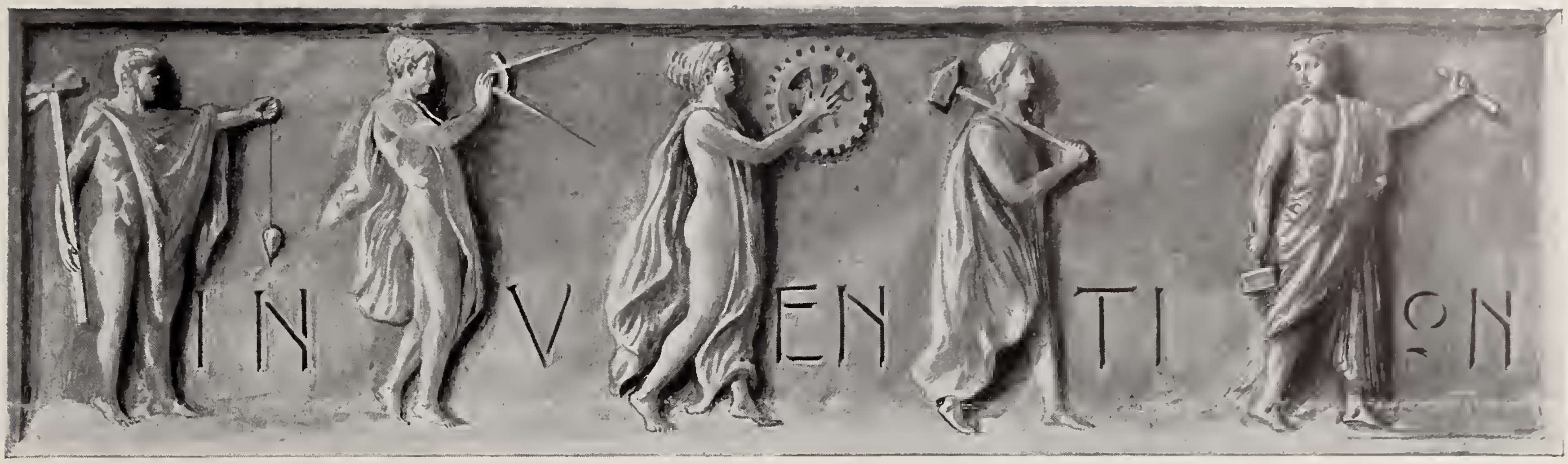
The belief in the preventive effect of lightning conductors is once more expressed by R. Klimpert, who argues that if we provided all the houses of a district with comb-like conductors, the atmospheric electricity would be dispersed before it could come to a real thunderstorm. Statistics have this question undecided; but it must be regarded as improbable that the little pins which we stick up would have any such effect.

Electric Steel Making at Niagara Falls

A PLANT for the manufacture of steel by electricity has been established at Niagara Falls by Marcus Ruthenberg, who for some time has been engaged at Lockport, N. Y., on experiments with a process covered by patents secured by him. A building has been rented from the Niagara Falls Power Company and machinery is being installed.

The Cleveland office of the United States Weather Bureau has entered into an agreement with the United States Telephone Company whereby the company will telephone the official forecast to every exchange of its own in the thirteen counties desiring it in the northeastern portion of Ohio.

The Vulcan Iron Works Company, Toledo, Ohio, manufacturers of steam shovels, dredges, boiler fronts, fittings, etc., recently posted a notice in their works to the effect that they will pay full time to any of its employees who are members of the Ohio National Guard, when out on parade with their company, at rifle practice, at camp duty, or when serving under the governor or sheriff to put down a riot.



Electrical and Mechanical Progress

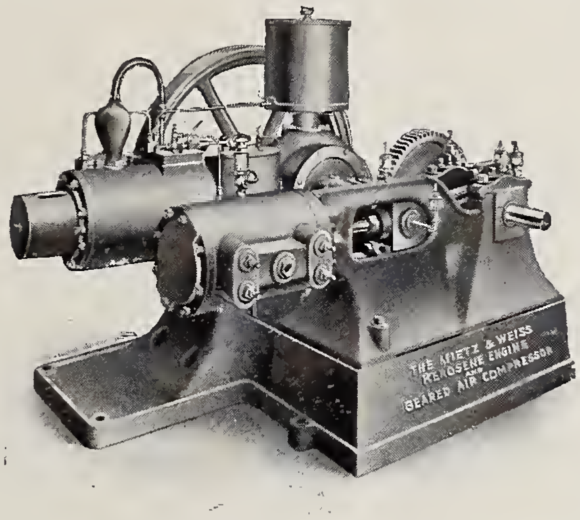
An Electric Water Cartridge for Coal Mining

SHOOTING down coal by steam generated rapidly from a cartridge of water instead of powder, is a new and interesting process described in a recent issue of "Electrical Mining." A small vessel filled with water and connected by wires to a source of electrical energy is tamped into the drill hole in the usual way. When the current is turned on the water is rapidly heated and steam is generated until finally the pressure rises so high as to overcome the resistance of the coal and the desired fall results. It is claimed that the quantity of water may be made such as to provide for any required pressure, insuring a good blast under all conditions; that the coal falls in larger blocks and with less screenings than when shot down by powder; and that comfort and safety are enhanced by the absence of powder smoke and the avoidance of dust explosions resultant from blown out powder shots. Samuel and Arthur Rogers, of Anniston, Ala., and Barnesville, Ohio, respectively, are the inventors.

The Mietz & Weiss Kerosene Oil Engine

THE well-established position of the gas or oil engine as an auxiliary in building construction, or for furnishing power where but a temporary plant is required, is exemplified in the erection of a new building at Forty-second street and Park avenue, New York. In the basement of this building the contractors have installed a kerosene oil engine, made by August Mietz, of New York, geared to an air compressor, made by the Clayton Air Compressor Works, of Brooklyn. The illustration on this page shows the engine and compressor as installed in the building.

The compressor is of the double-acting type, with a cylinder 8 by 8 inches, and compresses 70 cubic feet of free air per minute at a pressure of



A KEROSENE ENGINE MADE BY AUGUST MIETZ, NEW YORK, GEARED TO AN AIR COMPRESSOR MADE BY THE CLAYTON AIR COMPRESSOR WORKS, BROOKLYN

80 pounds. The compressed air is stored in a tank 6 feet by 18 inches, and furnishes power for operating five air drills used in connection with the structural iron work.

The engine runs at a speed of approximately 450 revolutions per minute, and drives the compressors through gearing of a ratio of 1 to 5. The horse-power developed is approximately 10. The engine consumes 9 gallons of kerosene during the daily run of 10 hours.

One interesting feature of the engine is the method employed to prevent carburization of the cylinder walls. The cooling water, after circulating around the engine cylinder jacket, passes to a trap fixed on the side of the cylinder, from which the steam developed by the heat of the cylinder walls is conducted to be mixed with the air for the explosive mixture. A ball float in the trap keeps the water at a constant level. It is claimed that by this method of introducing moisture into the explosive mixture carburization of the cylinder walls is prevented.

Electric Gathering Locomotives

THE distinctive feature of the electric gathering locomotive in mine service as compared with the usual form of electric mine locomotive is that it may be operated over tracks where there is neither trolley wire nor steel rails. This is made possible by carrying upon the locomotive a reel of flexible, insulated conductor. When it is desired to run on tracks where there is no trolley wire, the cable is connected to terminals provided for the purpose, and the locomotive is propelled by current taken through the cable.

A locomotive of this type, built by the Jeffrey Manufacturing Company, of Columbus, Ohio, is shown on the next page. The cable is automatically "paid out" as the locomotive runs away from the terminals, and is automatically rewound in even layers, with a uniform tension upon the reel, when the locomotive returns. The locomotive is always provided with a standard trolley, for use on portions of the haulage system where there is a trolley

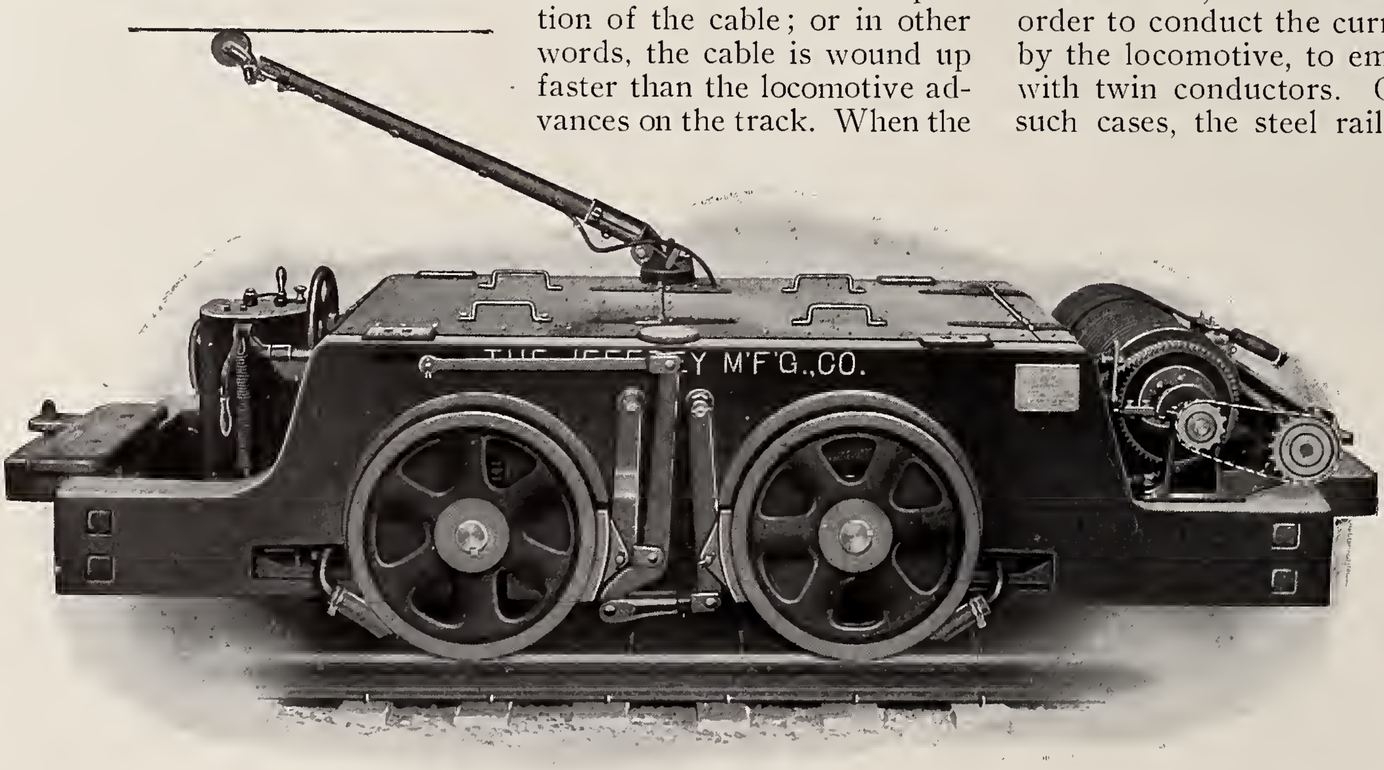
wire. A double throw switch connects the motors to either the trolley or the cable circuits. All electric contacts and conductors are inclosed in dust-proof compartments, so that it is absolutely impossible for a man to touch them unintentionally.

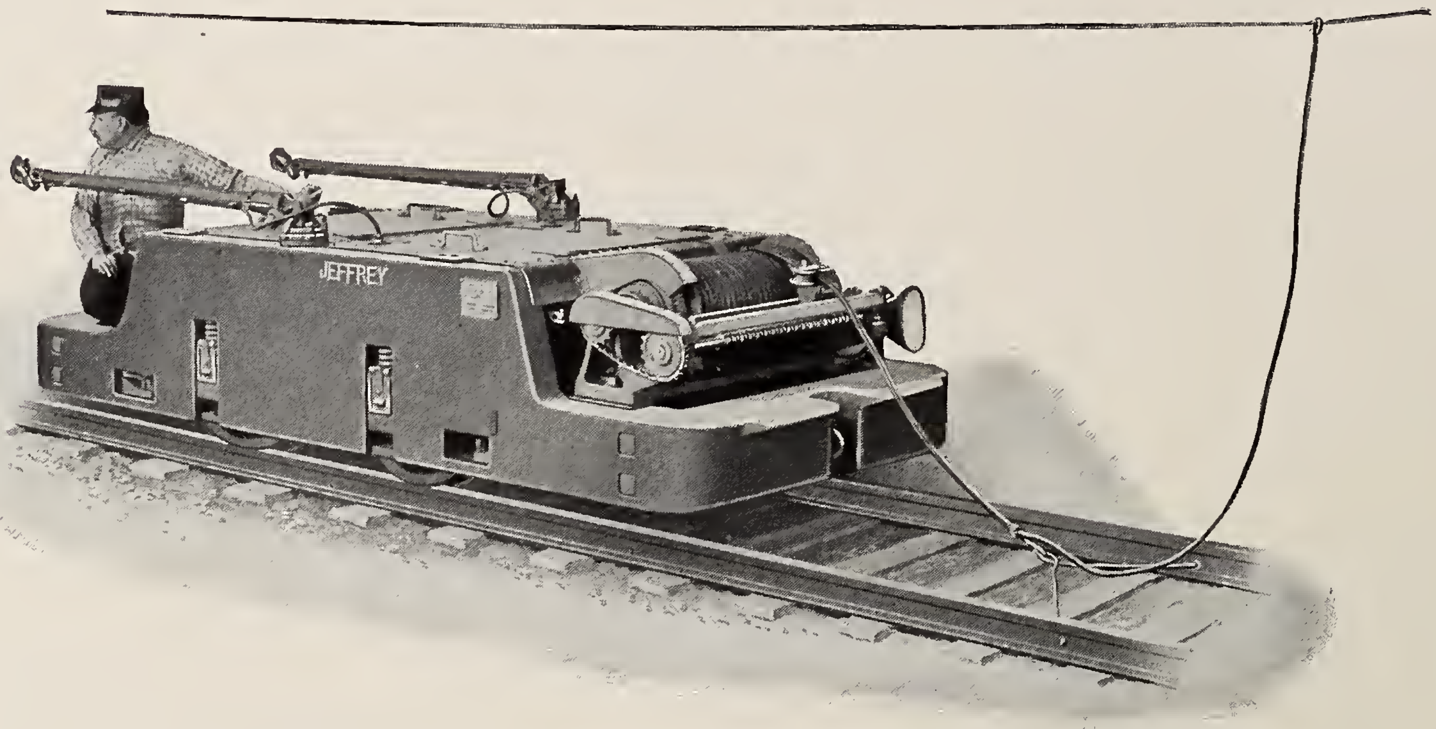
The cable-reel and spooling device are mounted at one end of the locomotive on top of the end frame. This construction gives ready access to the motors, and also allows the total height of the locomotive to be made as low as possible, a desirable feature for locomotives employed in thin-vein mines. Locomotives of this style are manufactured with a total height as low as 29 inches, which allows them to operates in mines where it would be impossible to work the smallest mule obtainable.

The reel is operated by a friction-clutch, positively driven by a silent running chain and sprocket from the motor, the control of the clutch being placed within easy reach of the motorneer at the operating end of the locomotive. The speed of the cable-reel, when the cable is being wound up, is such that it tends to produce a slight tension in the unwound portion of the cable; or in other words, the cable is wound up faster than the locomotive advances on the track. When the tension of the cable is increased the friction-clutch allows the reel to slip, and thus prevents injury to the cable from excessive tension. The clutch can be adjusted to produce any desired tension on the cable. From practical tests it has been found that about 25 pounds is sufficient.

The cable may have either single or twin conductors. A cable with a single conductor is used when the tracks in the rooms are laid with steel rails. The rails in such cases must be bonded or connected so as to form a continuous length, to insure a good return circuit. For bonding the rails in the rooms it is sufficient in many cases to simply clamp the bond-wire between the fish-plates and the rails.

When the track in rooms is laid partly with steel and partly with wooden rails, it becomes necessary, in order to conduct the current required by the locomotive, to employ a cable with twin conductors. Of course, in such cases, the steel rails do not require bonding. When the locomotive reaches a portion of track over which a trolley line is installed, the clutch is thrown out of engagement, the cable disconnected from the line and the trolley is used to collect the current for the locomotive motors. On running over a portion of track not provided with a trolley line, connections to the trolley wire and rail-bond wire are sometimes made by hooks soldered to the free





ELECTRIC GATHERING LOCOMOTIVES MADE BY THE JEFFREY MANUFACTURING COMPANY, COLUMBUS, OHIO

CAR PUSHERS AT THE MASSACHUSETTS COTTON MILLS, AT LOWELL, BEFORE THE COMING OF THE ELECTRIC LOCOMOTIVE

ends of the cables, and so secured as to safely withstand the tension put upon the cable by the reeling service.

Use of the Stroboscope

It is a peculiarity of vision, says "Machinery," that impressions on the retina do not fade instantly but persist for a fraction of a second after a change has taken place in the position of the object viewed.

This persistence of vision is what enables a fairly good view of a fair ground or baseball field alongside of a railroad track to be seen from the window of a rapidly-moving train, when, if the train were standing still, all that could be seen would be a high fence with narrow cracks between the vertical boards. When the car carries one by the fence rapidly the eye receives a series of views of the field through the cracks, which blend together and give the panorama effect.

This peculiarity is taken advantage of in investigating the action of certain vibrating or revolving mechanisms, as engine fly-wheel governors and the like. If a rapidly-running fly-wheel governor be seen for a fraction of a second at one spot at every rotation, it appears to the eye to stand still, and under that condition the in-and-out movements caused by changing load may be readily seen.

One method of obtaining this effect is to mount a radially-slotted disc on the fly-wheel shaft so that the slot covers the portion of the governor to be watched. In front of this disc is another slotted disc which stands stationary. Now, if a strong light illuminate the object, a flash of reflected light will reach the eye at every revolution.

The same stroboscopic effect was obtained in another way in the elaborate investigations of the Pelton water-wheel which were carried on some months ago. To perfect the shape of these buckets so that they should have the maximum of efficiency and durability it seemed necessary to observe the action of the jet as it impinged on the buckets, but to allow a perfect visual impression the buckets ought to stand still, which, of course, was impossible in running tests.

An arc lamp was arranged with a shutter, which was worked in synchronism with the revolving water-wheel. At every revolution a flash of light was directed upon the jet and buckets, giving them the appearance of standing still while the water entered the buckets and flowed out at the sides. With the same apparatus instantaneous photographs of both the jet and the buckets were taken.

A Storage Battery Factory Locomotive

The Massachusetts Cotton Mills, at Lowell, recently put into service a broad-gauge storage-battery locomotive, made by the C. W. Hunt Company, of West New Brighton, N. Y., for delivering carloads of baled cotton into the storerooms at both ends of the mills.

Before the adoption of this locomotive, the cars were moved, one at a time, by three horses harnessed in tandem. The storerooms are so constructed that the horses had no means of exit if driven in ahead of the car, so that the car had to be sent in "on the fly." By starting some distance back, speed was attained, and, at the proper moment, the "tag-holder" unhooked the "tag" fastened to the traces from the front of the car. The danger of this method is obvious.

Sometimes, with a heavily-loaded car, the horses were unable to give it the necessary momentum and the services of a loading gang were required to push the car into the storeroom. This condition of affairs is shown in one of the illustrations.

With the introduction of the storage-battery locomotive, however, danger and delay in handling the cars were largely avoided. One man is all that is needed to operate the locomotive. In light switching service the batteries can be recharged at various times during the day while the loco-

TO-DAY THE MILLS USE A STORAGE BATTERY LOCOMOTIVE FROM THE WORKS OF THE C. W. HUNT COMPANY, NEW YORK

motive is waiting between hauls. For heavier service they can be charged during the noon hour, or after working hours in the evening.

There is a separate gear case for each motor, so that in an emergency, or when through accident or other cause one motor is disabled, the locomotive can be operated with the other motor. This, of course, means a corresponding reduction in the hauling capacity, yet it permits the continued use of the locomotive.

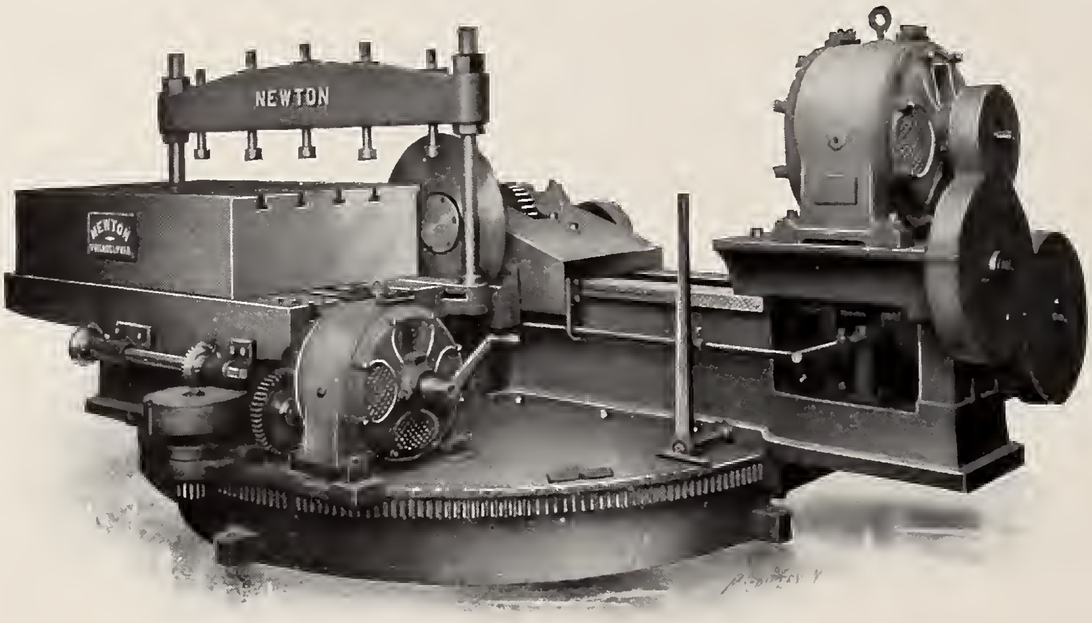
The entire absence of fire risk makes the storage-battery locomotive a valuable and safe means of handling inflammable and explosive materials. A steam or a trolley electric locomotive was out of the question in this instance on account of the attendant fire danger.

A Motor-Driven Cutting-Off Machine

THE present time in the history of machine tool development might well be called the motor-drive age. Not only is the application of motor drive being made to the actual work on the piece in hand, but also to the carrying on of auxiliary operations. In the combination cold saw cutting-off machine, made by the Newton Machine Tool Works, of Philadelphia, and illustrated on this page, one motor is used for operating the saw and another for turning the machine on its base.

The machine is intended for use in bridge and structural iron shops. It is also employed to advantage in any shop using I-beams, channel bars, angles and other long work on which it is desired to make either a straight or mitre cut. By being mounted on a round base, the machine may be swiveled to the desired angle, thus doing away with the crowding and confusion which must necessarily attend the swinging of a long beam diagonally across the shop where a fixed machine is used.

The machine has a saw blade 26 inches in diameter, and has a capacity on the top table for any sections 7 x 24 inches, and a capacity for I-beams on a square or mitre cut on the bottom table of 15 inches. For round stock, placed in a V-block which bolts to the bottom of the table, it has a capacity up to 7 inches. The V-block and auxiliary, or top table, are both made removable, the top table being intended for use in cutting any section up to the capacity of the saw, such as a number of tee or girder rails and plates. I-beams too large to be cut on the side may be laid flat. By removing the top table and V-block the machine can be used for cutting off gates or risers on small steel castings.



A COMBINATION COLD SAW CUTTING-OFF MACHINE MADE BY THE NEWTON MACHINE TOOL WORKS, PHILADELPHIA, PA.

The spindle can be fitted with a cutter head, thus being transformed into a rotary planer, and it can then be used for milling off the end of small built-up columns, or any other work requiring a finish on the end. The spindle is driven by a 5-H. P. motor through spur gearing, a phosphor-bronze worm wheel and a hardened steel worm of steep lead. The motor may be connected to the driving shaft with spur gearing, by the use of a silent chain, or by belting from the armature shaft to the driving shaft. The saw carriage has a wide range of variable feeds by means of a friction disc. It has a power quick return and is fitted with automatic stops and throw-out feed.

A 3-H. P. motor is also used to revolve the machine on the round base, though this is not essential, as the machine can be readily and easily revolved by hand.

Electric Motor-Driven Lathes

IN commenting on the change in lathes from the step-cone to the "all-gear" head, in which the change of speed is made entirely by gears, "The Engineer," of London, is of the opinion that while the change was due largely to the introduction of high-speed steels, a movement had already begun in the machine shop in favor of greater economy which made the change assured.

"The advantages of the all-gear head," says "The Engineer," "are its neatness, a no small asset in machine tool design, and the ease with which it is manipulated; against it may be urged the fact that it is without the resilience or elasticity which is found in cone-driven machines, a fact which occurs in its most aggravated form when the lathe is coupled direct through gearing to an electric motor. As long as the machine is used well within its power this is not a matter of much consequence, but when opportunity offers and the lathe is pressed to its uttermost, when it is taking a maximum cut at maximum speed, the danger of a catastrophe is always imminent. Some slight accident, some variation in the nature of the metal or of the size of the work may be sufficient either to throw the work out of the centers, with possible damage to the operator, the lathe, and itself, or to strip the gearing. That such accidents are frequent we will not say, but we imagine there is scarcely a works manager to be found who has not met with a few in his experience. Perhaps it will not be out of place to urge the advisability of taking a wrinkle from rolling mill practice, and provide a weak spot somewhere in the circuit.

"Accidents of this kind are most likely to occur in shaft turning, and in such cases it is an easy matter to use a driver that will either slip on the work if the stress becomes too great, or, if that be not possible, will give way before more serious damage is done. At least one well-known firm making a specialty of drilling machines with all-gear heads has recognized the advisability, to say the least of it, of providing no 'safety valve,' and has introduced a frictional device which slips under an excessive stress. Many lathes are already provided with something of the sort in their friction heads, and it would certainly be no difficult matter to introduce it into all machines intended for high service.

"We have on many occasions animadverted on the inadequacy of the

electro-motors provided for machine tools, and this is a good opportunity to impress on electricians again the great opening there is for a motor which will give the range of speed that is required in machine tools, and so rid us at once of the complications which the requirements of the machine shop enforce. A great advance has been made, but we still look for the day when the electric lathe shall no longer be a make-shift, but a composite and harmonious whole, when our motor shaft and our lathe spindle shall be one, when our feeds shall be operated without gearing, and our various manipulations effected by the pressing of buttons, and when the cam drum of the automatic lathe shall be replaced by a rotary switch the size of your fist. Who shall say that such things are impossible, and who shall say that there are no chances for our scientific engineers while a variable speed motor which will meet the requirements of the machine tool maker is yet to be invented?"

An Electric Oven for Chemists

CHEMISTS, in evaporating solutions of various kinds, often desire a heat of constant temperature—more constant than can be obtained from a direct-heated plate when the gas pressure changes. A contributor to "The Cement and Engineering News" describes an oven for this purpose which is heated by incandescent lamps.

This oven has among its advantages cleanliness, durability and evenness of temperature. By its use analyses may be started in the evening and the solutions left to evaporate during the night. The oven consists of a copper box 35 inches long, 4½ inches deep and 5 inches wide. The cover is made to fit the top of the oven closely, and may be arranged to be held in place by bolts.

The apparatus stands on six iron legs. This enables the operator to turn on or off any lamps desired. Sockets should be soldered firmly in place. The lamps are connected in parallel, and the circuit equipped with a cut-out switch.

In the usual construction seven 32 candle-power lamps are employed. The cover, which fits tightly on the oven, has six holes 3¾ inches in diameter. These holes are placed midway between adjacent lamps. Lids can be made to close the openings of the oven, an opening being cut in the lid 2 inches in diameter, which fits a 250 cubic centimeter Jena beaker. If only three or four solutions are to be evaporated, only four or five lamps need be operated; the rest of the openings can be covered with a circular plate.

The Increasing Size of Electric Generators

THE main service plant at the St. Louis Exposition, for which the Westinghouse & Electric Manufacturing Company received the general contract, is naturally a notable feature of the Westinghouse exhibits, and one which appeals to practically all visitors to the fair, because of the commanding size of the four big electric generating units, each of 2000-kilowatt capacity, and their location in the central aisle of Machinery Hall.

At Chicago, in 1893, the great central station plant, which also was installed by the Westinghouse Company, was a complete exhibit of the most modern type of electrical machinery at that time, and the twelve 750-kilowatt generators, each at 2200 volts, were the largest alternating-current polyphase machines ever constructed, and constituted the largest polyphase plant then in service. The 2000-kilowatt three-phase alternating-current generators of the St. Louis plant, which run at a speed of 83⅓ revolutions per minute and deliver a 25-cycle current at 6600 volts, although of almost three times the individual capacity of those seen at Chicago, and though they help, in a measure, to illustrate the growth in generator size, are not at this day particularly remarkable on account of their size. The elevated and subway train service in New York, for example, is rendered by 5000-K. W. generators, while at Niagara Falls 10,000-K. W. machines have been installed.

An Electric Lighting Plant in British Central Africa

AN electric lighting plant in the town of Zombo, in British Central Africa, described in "The Electrical Review," of London, is operated by a 24-inch, two-nozzle Pelton wheel of 26 H. P., worked with a 180-foot head of water.

The plant is the property of the Administration of the British Central Africa Protectorate, and is used only for lighting the bungalows of the civil officials. The Pelton wheel drives machinery, saws, planing machines, etc., in the carpenters' shop from 6 A. M. to 5 P. M., and is used from 6 P. M. to midnight to drive the two dynamos, each compound-wound, 800 revolutions per minute, 35 amperes capacity, at 220 volts. These are not coupled up either in series or parallel, but work independently.

Some thirty-three bungalows are lit up at present, with a total of about 400 equivalent 8 candle-power lamps. The current is distributed from the electrical station along four main leads, of bare copper wire carried on wooden poles. These leads are protected from lightning by barbed wire running between the lead and return, and connected to earth at every alternate pole.

Horn pattern lightning arresters are also provided at the distributing centres, connected to earth by copper plates, in contradistinction to the barbed wire earth-plates of corrugated iron. So far, no street lighting has been carried out.

The capital expenditure per K. W. installed is £36 4s. 6d., the total running cost being 4s. per 8 cande-power lamp per annum, including 5 per cent. interest on capital expenditure and 5 per cent. depreciation. The price per unit is 6s. per 8 candle-power lamp per annum, this basis of measurement being adopted to save bookkeeping. The figures appear to be low all around.

The staff is very small, no European's salary being chargeable, as the engineer has only a nominal appointment, and two natives, whose total wages are 35s. a month, keep the machinery in order. The installation is not run for a profit, the charges being arranged only to pay interest, depreciation and working expenses.

Personal

Arthur Visick, formerly of the Napier Company, of England, manufacturers of motor cars, has been appointed representative at St. Louis for the Packard Motor Car Company, of Detroit, Mich. Mr. Visick has had a wide experience abroad in connection with the Wollsley and Napier factories, which will be of value to him in furthering the interests of the company.

Albert Ladd Colby, metallurgical engineer of the International Nickel Company, who was stricken with pleurisy recently at St. Louis, where he was installing the exhibit of the company, has, happily, recovered his health.

James W. Lyons announces his resignation as manager of the power department of the Allis-Chalmers Company. His resignation took effect on August 13. Mr. Lyons has taken this step in order to accept the

appointment as consulting engineer to the Elgin Watch Company, of Elgin, Ill., who will erect new and extensive works under his supervision. Mr. Lyons will also engage in other consulting work and his headquarters will be at Chicago. Mr. Lyons takes with him the good wishes of all his former associates in the Allis-Chalmers Company.

H. W. Young, formerly at the General Electric Company's works at Schenectady, is now connected with the National Electric Signalling Company, of Pittsburg, in the capacity of sales manager.

Prof. W. A. Anthony, while riding a bicycle recently in New York, was run over by a heavy ice wagon, causing a fracture of the hip bone.

Dr. F. A. C. Perrine, who recently resigned from the vice-presidency and general management of the Stanley Electric Manufacturing Company, as noted in these columns, has been elected president of the Construction Company of America, which controls franchises for various light, power and railway systems in the West.

William J. Hammer, of New York, has been appointed a member of the International Board of Jurors, at the St. Louis Exposition. Mr. Hammer's wide experience in the electrical field will make him a most valuable acquisition to the board.

R. M. Jones, who for the past five years has been identified with the Pike's Peak Power Company, of Victor, Col., in the capacity of chief engineer and general superintendent, has severed his connection with that company. Mr. Jones is now located at 1455 Josephine street, Denver, Col., and is prepared to take up new work in hydraulic and electrical installations either as consulting or construction engineer.

Roscoe Cornell has been appointed manager of the branch office which the Allis-Chalmers Company has just opened in El Paso, Tex. Mr. Cornell goes to the Allis-Chalmers Company from the Mine & Smelter Supply Company, of Denver. He is a graduate of the Michigan College of Mines, and is well known as a mining and mechanical engineer. He has held a number of prominent positions as a mining engineer and as a smelter and mine superintendent. His acquaintance is extensive, and he is thoroughly qualified to fill the important position to which he has just been appointed.

Trade News

The Buffalo office of the Nernst Lamp Company, in charge of Mr. G. E. Bennettt as district manager, has recently obtained the contract for lighting the new Albright Art Building of Buffalo, with Nernst lamps. The contract provides for the use of over 200 six-glower, and a number of three-glower lamps. This building, as planned by the architects, Green & Hicks, of Buffalo, is of pleasing architecture, and ranks among the handsomest of its kind in the country. It was donated to the city by Col Albright, a prominent and wealthy citizen. Tests were made by the architects, with the aid of Mr. Bennett, to compare the Nernst with the arc and incandescent electric system, special attention being given to the respective abilities of the illuminants in bringing out the natural tints of the paintings and the architectural features of the interior. One unique feature of the lighting scheme is the location of the lamps for lighting the art galleries; all lamps are placed above the false skylight ceiling, so that no lamps are visible from the interior, and the light is projected through from above so as to strongly and evenly illuminate that portion of the side walls occupied by the paintings. Another important installation is the one in present service in the Art Buildings at the World's Fair. Over 1500 three-glower Nernst lamps are used to illuminate the interior of these buildings, and the results are conceded to be of unusual excellence.

At a meeting of the board of directors of the Bullock Electric Manufacturing Company, of Cincinnati, Ohio, held on July 30, W. H. Whiteside, general manager of sales of the Allis-Chalmers Company, was appointed general manager of sales of the Bullock Electric Manufacturing Company. Mr. Whiteside will have entire charge of the sales department of both the Allis-Chalmers and Bullock organizations.

The Keystone Electric Company, of Erie, Pa., have leased their entire plant and assets to the Burke Electric Company. The latter company will manufacture direct and alternating-current dynamos and motors under the patents and personal direction of Mr. James Burke. Herbert B. Coho will direct the sales organization of both companies, with headquarters at the factory in Erie.

The National Electric Company, successor to the Christensen Engineering Company, of Milwaukee, Wis., manufacturers of Christensen air brakes and electrical machinery, have just completed extensions to their foundries, and are soliciting orders for open hearth, crucible steel, semi-steel, iron and brass castings.

The Frick Company, of Waynesboro, Pa., builders of the "Eclipse" ice making and refrigerating machinery, Corliss engines and steam boilers, have an elaborate display of their machinery at the St. Louis Exposition.

Manning, Maxwell & Moore, of New York, have secured a large order for electrical traveling cranes to be distributed at the various shops of the Illinois Central Railroad. This order is part of a larger one for machine tools amounting in value to about $160,000.

The Broderick & Bascom Rope Co., St. Louis, Mo., have received considerable praise for their exhibit of wire rope at the St. Louis Exposition. To enable their employees to view this result of their skill, the company closed the factory for an entire day and provided 300 or more employees and their families with admission tickets to the Fair and to several of the attractions on the "Pike."

The Pelton Water Wheel Company, of San Francisco, has just closed a contract with the Waipori Falls Electric Power Company, Ltd., of Dunedin, New Zealand. This consists of two Pelton water wheels of 2000 horse-power capacity each for direct connection to 1000-kilowatt, 400 revolutions per minute. General Electric generators. The effective head available is 665 feet, obtainable through 1825 feet of sheet steel riveted pipe, varying in diameter from 42 inches to 36 inches, the latter at the lower end being 1½ inches in thickness.

During the past year the Automatic Electric Company, of Chicago, offered to Sibley College a complete automatic telephone, for use in connection with the course in telephone engineering. Later they enlarged their gift to include a complete outfit to replace the old bridging telephone system which had been in use between the offices of the heads of the departments of the college. The new system consists of ten of the Automatic Electric Company's telephones, four of the wall type and six of the desk type, and one special section of their automatic switchboard of the 1000-line type.

The Nernst lamp is fast becoming introduced in the West for all kinds

of commercial electric lighting service. The Denver office of the Nernst Lamp Company, in charge of Mr. R. D. Marthens, has lately received contracts for lighting the United States Army Post at Fort Logan, Colorado, and also the Central Drug Company, A. A. Turnace Billiard Hall, and the Schilling Mercantile Company, all of Cripple Creek, Col. In each instance, the Nernst lamps replace incandescent systems.

New Catalogues

An attractive booklet devoted to the Westinghouse industries as exemplified at the St. Louis Exposition has been issued by the Westinghouse Companies' Publishing Department, of Pittsburg. The booklet contains illustrations of the main and subsidiary plants controlled by Westinghouse interests at home and abroad, with a brief history of the organization and development of each company. The exhibits of the several companies are illustrated and described, together with other installations made in the regular course of business.

Engine type generators for direct current are illustrated and described in a new bulletin sent out by the Bullock Electric Manufacturing Company, of Cincinnati, Ohio. The main features of design are shown and described in detail, and numerous views are given of these direct-connected machines as installed in various plants. The pamphlet also contains tables of ratings and approximate dimensions.

The Cutter Company, of Philadelphia, are sending out a pamphlet describing and ilustrating the circuit-breakers of their manufacture. The action of the circuit-breaker is explained with the aid of diagrams, and the advantages of the instrument under various conditions of service are fully set forth. The pamphlet contains tables of capacities and diagrams of connections for motor, generator and feeder service. The company have also issued a circular announcing that they are prepared to supply their customers with all types of measuring instruments made by the Weston Electrical Instrument Company.

A new catalogue circulated by the Billings & Spencer Company, of Hartford, Conn., treats of the drop hammers, trimming presses and heating furnaces made by that company. Several types of each of the foregoing are illustrated and their more important features are briefly described. A table of dimensions of concrete foundations for drop hammers is given, and several pages are devoted to illustrations of drop forgings made with the company's hammers.

Recording pressure and vacuum gauges are illustrated and described in a new catalogue sent out by the Bristol Company of Waterbury, Conn. The mechanisms of the various types of gauges are shown and explained in sufficient detail to enable the reader to obtain a clear idea of their working, and tabulated data of the working range and specimen chart sections are given. The pamphlet also illustrates and describes the inking outfit, the chart cabinet, the protecting and the carrying cases used in connection with these instruments.

"Machine Tool Drive" is the subject of a catalogue recently issued by the Westinghouse Electric & Manufacturing Company, of Pittsburg, Pa. The multi-voltage, the unbalanced voltage, the balanced voltage and the single voltage systems are discussed at some length. The pamphlet contains numerous excellent illustrations of machine tools adapted for motor-drive.

A folder illustrating and describing the "Knowles Express Pump" has been issued by the Knowles Steam Pump Works, of New York. The pump is of the reciprocating type and is direct connected to a motor. The folder sets forth briefly the advantages of this pump for use in mines.

A new bulletin issued by the General Electric Company, of Schenectady, N. Y., illustrates and describes the oil switches made by the company for use with high-tension currents. Besides tables of capacity, the pamphlet also contains wiring diagrams for remote controlled switches and diagrams of the mechanism used for panel operation. Another bulletin is devoted to street lighting by the series, direct-current, enclosed-arc system. This illustrates and describes the arc lamps, arc cut-outs and hangers used on the system, and also the street poles and Brush arc generators. Voltage regulators for direct-current generators are also illustrated and described in a pamphlet issued by the company. Two separate catalogues are devoted to lists of repair parts of the railway motors known as GE 73-C and E, and CB-15-G. Flyers have also been issued dealing with combined sockets and shade-holders, ceiling rosettes and copper cable terminals. A leaflet is also devoted to parallel rod direct-current enclosed arc lamps.

Compressed air hauling is discussed in a catalogue issued by the H. K. Porter Company, of Pittsburg, Pa. The various types of compressed air locomotives made by the company are illustrated, several of the views showing the locomotives in actual service. The compressors built by the company for use in connection with the locomotives are also illustrated. A comparison is also made of the cost of hauling by compressed air and by electricity.

The water tube boiler built by the Rust Boiler Company, of Pittsburg, Pa., is illustrated and described in a new catalogue sent out by that company. The main features of design are shown, and their advantages are pointed out.

A booklet illustrating and describing the power transmission systems established by the South Bend Electric Company and the St. Joseph & Elkhart Power Company, of South Bend, Ind., the Elkhart Electric Company, of Elkhart, Ind., and the Buchanan Company, of Buchanan, Mich., has been issued by these allied companies in a very attractive form. A map shows the location and extent of the systems, and numerous illustrations are given of the plants using the electric power developed through the agency of the St. Joseph River, together with the machines operated by motor-drive. The latter portion of the booklet illustrates and describes the attractive features of the valley of the St. Joseph and its progressive cities.

A booklet illustrating and describing the social institutions established by the Weston Electrical Instrument Company, of Newark, N. J., contains some interesting information as to the relations between employer and employee existing at the company's works. The booklet is really a history of the birth and development of the Weston Employees' Club, an organization created by the company but carried on by the employees themselves. Illustrations are given of the dining-hall, library, kitchen, billiard-room and natatorium. A brief description of the manufacturing departments is also given, together with illustrations of the main shop.

Instructions for the care and operation of direct-current electric generators built by the Jeffrey Manufacturing Company, of Columbus, Ohio, have been issued by the company in pamphlet form. The pamphlet illustrates two generators of the Jeffrey type, and besides the instructions, dia-

grams are given showing the wiring connections for clockwise and counter clockwise rotation. A circular illustrating the Jeffrey grab buckets accompanies the pamphlet.

A library edition of a catalogue with the title "A System of Engines," has been prepared in an unusually attractive form by the Harrisburg Foundry & Machine Works, of Harrisburg, Pa. The catalogue is in book form, and the typography and engraving throughout are excellent. The Harrisburg boilers are also illustrated and described, and directions are given for the care and management of the Harrisburg engines.

Multi-phase revolving field generators are illustrated and described in a bulletin sent out by the Fort Wayne Electric Works, of Fort Wayne, Ind. The main features of the generators are shown and described, together with the direct-current exciter and combination alternator-exciter field rheostat used in connection with the company's alternators. Tables of dimensions are also given in the bulletin. Another booklet by the same company is devoted to transformers of the type used on poles in out-of-door service. The details of construction are illustrated and described, as are also the fuse blocks used in connection with the transformers. Wiring diagrams are also given for various conditions of service. The company have also issued a catalogue of repair parts for their alternating-current arc lamps.

The various uses to which rubber belt conveyors may be put are illustrated in a catalogue sent out by the Jeffrey Manufacturing Company, of Columbus, Ohio. The conveyors are shown in sufficient detail to give one a clear conception of their working. Steel and malleable iron bucket elevators and the wooden apron conveyors, with their modifications for various uses, are also illustrated. The catalogue further shows in part the coal and ore handling machinery made by the company. A separate pamphlet deals with the Jeffrey water elevators, illustrating and briefly describing the several types of machines used for hoisting water by means of an endless chain of buckets.

The Brill semi-convertible car is a type which, when closed in the usual way for winter use, may be converted for summer use by raising the windows and sashes, if need be, into pockets in the roof of the car. A catalogue recently issued by the J. G. Brill Company, of Philadelphia, gives a clear description, with excellent illustrations of the method of conversion. An isometric view of the bottom framing and a cross-section of the car are also given with the general dimensions of the standard car made by the company.

"What We Do" is the title of an attractive booklet issued by the Wellman-Seaver-Morgan Company, of Cleveland, Ohio. The booklet consists mainly of illustrations showing manufacturing buildings designed by the company and apparatus, such as steel works, machinery, gas producers, ore and coal-handling and mining machinery, coke oven machinery, and also hoists of various kinds.

The Bullock Electric Manufacturing Company, of Cincinnati, Ohio, have issued a booklet illustrating their generators, motors, rotary converters, transformers and multi-voltage balancers and controllers as exhibited at the St. Louis Exposition. Several views of portions of the company's works are also given in the catalogue, together with illustrations of generators installed at various plants. Another pamphlet sent out by the company illustrates and describes transformers.

Book News

Machine Design, Part I: Fastenings

By William Ledyard Cathcart. Published by the D. Van Nostrand Company, New York; 291 pages. Price $3.00 net.

The main purpose of this book, as stated in the preface, is to present in compact form for the use of the student and designer, modern American data from the best practice in the branch of machine design to which the work refers. The theoretical treatment of the subject has also been given fully.

The work contains five chapters: I. Shrinkage and pressure fits. II. Screw fastenings. III. Riveted joints; theory and formulæ. IV. Riveted joints; tests and data from practice. V. Keyed joints; pin joints. There are 77 tables and 119 illustrations. In the first chapter, shrinkage and pressure fits, the subject is treated under ten heads, covering 41 pages: 1, general fomulæ; 2, proportions of the joint; 3, metals; 4, forcing pressures; 5, shrinkage temperatures; 6, shrinkage vs. pressure fits; 7, stationary engines, data from practice; 8, marine engines, data from practice; 9, railway work, data from practice; 10, shrinkage in gun construction. In like manner screw fastenings, 85 pages, is treated under 24 heads; riveted joints, theory and formulæ, 45 pages, under 12 heads; tests and data from practice, 59 pages, under 7 heads, and keyed and piece joints, 39 pages, under 6 heads. Each subject is carefully discussed from the standpoints of both theory and practice. The references to original papers are numerous, nearly 100 authorities being quoted.

The text is written with great clearness, and the typography and illustrations, with a few exceptions, are excellent. On the whole the book appears to be the most thorough one on the subject which has yet been published, and it is to be hoped that the author will continue his work in this line, and give us a complete treatise on machine design, with especial reference to American practice, a treatise of which the engineering profession is in great need. We suggest that in future editions of Part I, the work might be improved by adding to it plates of curves showing the proportions used in practice and those deduced from theory, and empirical formulæ derived from them which may be used within stated limits for which they may properly be applicable. This would save the designer the trouble of close study of many pages of the text before he can select a formula suitable for a given case.

Static Electricity

By Hobart Mason, B.S., E.E. Size, 6 x 8½ inches; 152 pages. Published by the McGraw Publishing Company, New York. Price $2.

At first glance one questions the raison d'être of this book, but after a perusal of the author's preface and an examination of the text, it is seen that the book probably supplies a want that we were not sure had existed. The author admits that there is nothing original in his book, but he hopes that by a judicious combining of the wisdom of others in lucid and orderly fashion, which wisdom hitherto has been contained in papers so profound and inaccessible as to be beyond the reach of many, he has made a volume which will be found of value "to the student, the physicist and the casual seeker after electrostatic truths," and we are inclined to believe that such will be the case. The book is written in a clear and easy style and is not overloaded with mathematics. It is well printed, and the illustrations are well designed and executed.

The Thomas Discount Book

By Millward T. Thomas. Published by the author, Williamsport, Pa.; 81 pages. Price, in cloth, $1; leather, $1.25.

From the experience of his own work in figuring discounts, the author has realized the necessity of a more rapid method of obtaining net costs from price lists than the ordinary time-consuming one of calculation, and so originally evolved this book for his own use. It consists, in the main, of tables giving net costs of list prices ranging from 1 to 50. A marginal thumb index enables the user to readily find the table for each discount from the lowest of 2½ to that of 90, 10 and 2½. Each page includes seven discounts, these being arranged at the head of the page with the net prices in columns beneath. The list prices are in a single column at the left and the corresponding net price may be found by merely running along the row opposite till under the discount given.

The tables may, of course, also be used in a reverse way for finding the discount itself or for obtaining the list price from a given discount and net price. The methods of using the tables are fully explained, and examples are given showing their application.

Manual for Engineers

Compiled by Charles E. Ferris, B.S., Professor of Mechanical Engineering, University of Tennessee. Published by the University Press, Knoxville, Tenn.; 155 pages, 3 x 6 inches. Price, 50 cents.

The greater part of this booklet is a collection of tables and data drawn from various sources, of general interest to engineers and business men. There are tables of areas and circumferences, of circles, squares, cubes and reciprocals, natural trigonometrical functions and logarithms. Earthwork tables of some extent are given, as are also tables of bending moments for loaded beams and moments of inertia of different beam sections.

A number of pages are devoted to electricity, including copper wire tables, and wiring tables for low-tension and high-tension circuits. A table of cost of arc lighting for both direct and alternating current is also contained in this section. Quite a few formulæ are also given for cements used for adhesive purposes and for concrete work.

The Polytechnic Engineer

The annual organ of the Engineering Society of the Polytechnic Institute of Brooklyn. 170 pages. 7 by 10 inches.

The book includes a list of trustees, members of the faculty, members of the society, with its constitution, and nine articles on subjects of interest to electrical, civil and mechanical engineers. With the exception of the first articles by Dr. J. Brace Chittenden, of the faculty, the contributions are by active members of the society.

Dr. Chittenden's article on "The Potential Function" discusses the theory of the potential function employed in mathematical physics, particularly in connection with the phenomena of electricity and magnetism. "Electrostatic Generators," by O. H. Clarke, is the report of an investigation into the theory and properties of various types of Holtz machines. In "Commutating Single-Phase Series Motors," by R. W. Hutchinson, the adaptability to railway work of single-phase series motors and repulsion motors is considered. "A New Gas Turbine," by H. T. Lees; "Variable Speed Control," by J. M. Lloyd, and Factors Influencing the Economic design of Single-Phase Railway Motors," by O. H. Clarke, are interesting as topics coming prominently before the engineering world of to-day.

Other articles are: "The Amity Diversion Weir on the Arkansas River," by W. J. Berry; "The Dynamometer Car," by C. A. Crandell, and "Irrigation and Its Aplication in Colorado," by J. M. Wiley. The book also contains abstracts of lectures delivered before the society, and accounts of excursions of the society to the New York subway, various power plants and the like.

The Drafting Room Apprenticeship Course of the General Electric Company

By JOHN W. UPP

It is well known that large manufacturing companies have considerable difficulty in obtaining enough trained men who are familiar with the general practice of the company to fill the positions which are always open in the drafting room and detail engineering departments. This situation is being met, at least in one of the large manufacturing companies, by the employment of apprentices who are trained for drafting-room work.

The entrance requirements are not severe; boys from 16 to 18 years old, of good moral character, well recommended, who have been regular attendants at school, and who can pass an examination in advanced arithmetic, are selected for trial. This trial period extends through one month or more, at the end of which time a general knowledge has been obtained of the young man's personal characteristics. If he has proven himself a diligent worker, and there is evidence that he would make a satisfactory employee, and he has shown an inclination to apply himself to drafting-room work, he is accepted as a regular apprentice. He then signs an agreement, endorsed by his parents, to remain in the company's employ four years, for which he is to receive a moderate compensation, which increases from year to year.

As soon as the apprentice has been regularly employed, he is turned over to an instructor, who tries to find the weak points in his previous education, and lay out a course of study which shall include instruction in algebra, geometry, trigonometry, descriptive geometry, applied mechanics, and their general application to drafting-room and general engineering problems.

Regular recitation hours are arranged, at which time the apprentice comes in personal touch with the instructor and is encouraged to excel, the classes being purposely kept small to permit rapid advancement.

From the beginning the apprentice follows a regular line of production work. Starting in the blue-print department, he learns how to make blue prints, and has the importance of having all tracing clear and distinct, with good figures and letters, firmly impressed upon him. He is also given preliminary drawings to copy, his work being inspected once a week and faults corrected. These drawings are sheets of instruction, and are first penciled on paper and then inked in on tracing cloth. He makes blue prints of his own tracings, and his work is not passed as satisfactory until there is evidence that he can handle his instruments skillfully, and that he can make reproductions which will be acceptable to the foreman of the tracing department.

The blue-print department assignment is usually completed in six months; then, if he has proven his eligibility as outlined in the foregoing, he is transferred to the tracing department as a tracer. For the first few weeks the greatest stress is laid upon neat work, but the ambitious ap-

prentice is soon encouraged to do quick work by the arrangement of piece-work prices, which permit him to earn a small bonus in addition to his stated compensation. While he is in the tracing department, where he is in daily and hourly contact with detail drawings, he is given systematic instruction on the best method of arranging details, and is required to make drawings of the least complicated parts of some standard machine, the complete details, assembly and cross section of which are to be finished when he is further advanced.

At the end of the first year, and if it has been demonstrated that the young man can do neat and accurate work, he is transferred to the factory, as it is well known that few draftsmen have a proper conception of shop requirements unless they have, at some time or other, worked in a factory long enough to become familiar with the use and limitations of machine tools.

The apprentice remains in the factory a varying time, but not less than one and one-half years, and, when possible, arrangements are made to have him spend a short time in the foundry and pattern shop; but a greater portion of the time is spent in a detail machine department, where he works from drawings and produces the articles called for.

His drawing-room work is not neglected during his shop experience, as he is given additional instruction and is required to produce the remainder of the detail drawings of the machine, which were started when he was in the tracing department.

At the end of his shop work, and if it be shown that he can read and work from drawings, he is retransferred to the drafting room, this time as a detail draftsman; as it is the intention to make him an expert in the development of some special line of apparatus, he is assigned to a specialized drafting section, where the greatest benefit can be obtained from the instruction which he has already received. He starts work on the minor details, and gradually progresses under the instruction of the foreman until he is competent to handle the most intricate detail work. If the apprentice be ambitious, his progress is surprising and gratifying.

At the end of the four years there is a final examination, which is thorough and covers all the work of the previous years. If this examination be passed and his previous record have been satisfactory, he is given a certificate of proficiency and a cash bonus and is then eligible for regular employment in the drafting room, where he is encouraged to remain, having been trained for the position to which he will now be assigned.

Even though the completion of the work set for the four years requires very close application, it is found that a very large percentage of the young men who are engaged as apprentices qualify as draftsmen. They take a marked interest in their work, and while it is necessary for them to do some work outside of the regular hours, there is enough time for recreation. Those who fail to qualify either lack ambition or it is found that they are naturally not fitted for drafting-room work.

The experience which has so far been obtained from the operation of the apprentice course as outlined has been so satisfactory that it indicates the advisability of making this work of instruction a regular part of all large drafting-room organizations.

Selections can be made from applicants who need not be limited to any single class, the son of a mechanic, farmer or tradesman being insured practical instruction from those best fitted to give it, and the probability of permanent position if his ability warrants it.

Electric Power in Marble Quarries

AN interesting example of the fact that water powers, though of comparatively small proportions, may yet by proper engineering be developed into fruitful sources of energy, is shown in the utilization of the flow of Otter Creek, in Southwest Vermont, to provide the working force for the largest marble quarries in America.

Between Rutland and Proctor, a distance of 6 miles, the stream has a fall of 165 feet. At Proctor a power plant was built, and two sets of turbines in pairs were installed. One pair, developing 750 H. P., operates the generators for furnishing power to the works at Proctor. The second pair of turbines operates two generators of a combined capacity of 500 K. W. and another generator of 75 K. W. capacity. The former furnish the current for transmission to the works at West Rutland, at a voltage of 3500. Another plant at Center Rutland also utilizes the water power for rope driving and electric generation.

As blocks weighing 25 tons are taken from the Vermont beds, the method of storing and of transferring them from place to place is one of the most important mechanical features. For this, electric power is extensively employed. One of the largest cranes used in the work is a gantry crane at West Rutland, serving the storage yard at that place, and having a total lifting capacity of 30 tons. It is shown on page 159. It has an overhang of 50 feet on either side of the track on which it is mounted. As this track is 60 feet in width, the crane can handle blocks in a lateral direction a distance of 160 feet, and can pile them to a height of about 40 feet. The bridge is moved by a 50-horse-power motor, and is equipped with two trolleys of 25 tons capacity each, the separate trolleys having individual 30-horse-power hoist motors. The track of a steam railroad extends under this crane to facilitate the loading and unloading of trains.

Another type of crane used is a half gantry of 15 tons capacity, shown on page 159, and also used for train loading. It has a 22-foot span, with a hoist motor of 21 horse-power, a trolley motor of 10 horse-power, and a bridge motor of 30 horse-power. Its outer end is supported by a steel tower moving on the ground rail, while the inner end rests on a truck mounted on an elevated track attached to one of the buildings.

All of the larger pieces in the various shops are also handled by cranes. In the building-material mill at Proctor there is a three-motor electric crane of the same capacity and horse-power as the half gantry just mentioned. The voltage in each case is 220; this is true also of a yard derrick in use at Proctor, having an 8 horse-power motor.

Another use to which electricity is put in these quarries is for operating the motors which drive the gadders. Practically all of the material in the quarries is separated by channelers and gadders, the former being steam-driven and the latter, as already indicated, motor-driven. Each machine has an individual motor mounted on the frame and direct connected to the shaft which drives the drills. The motors are of 8 horse-power, representing the same amount of power as when steam is utilized.

Extensions are now being made to enlarge this system of power distribution so that every operation may be done by means of electricity. As at present, the main power plant will be at Proctor. A series of three turbines, of 1000 horse-power each, will be substituted for the ones now in service. They will have a working head

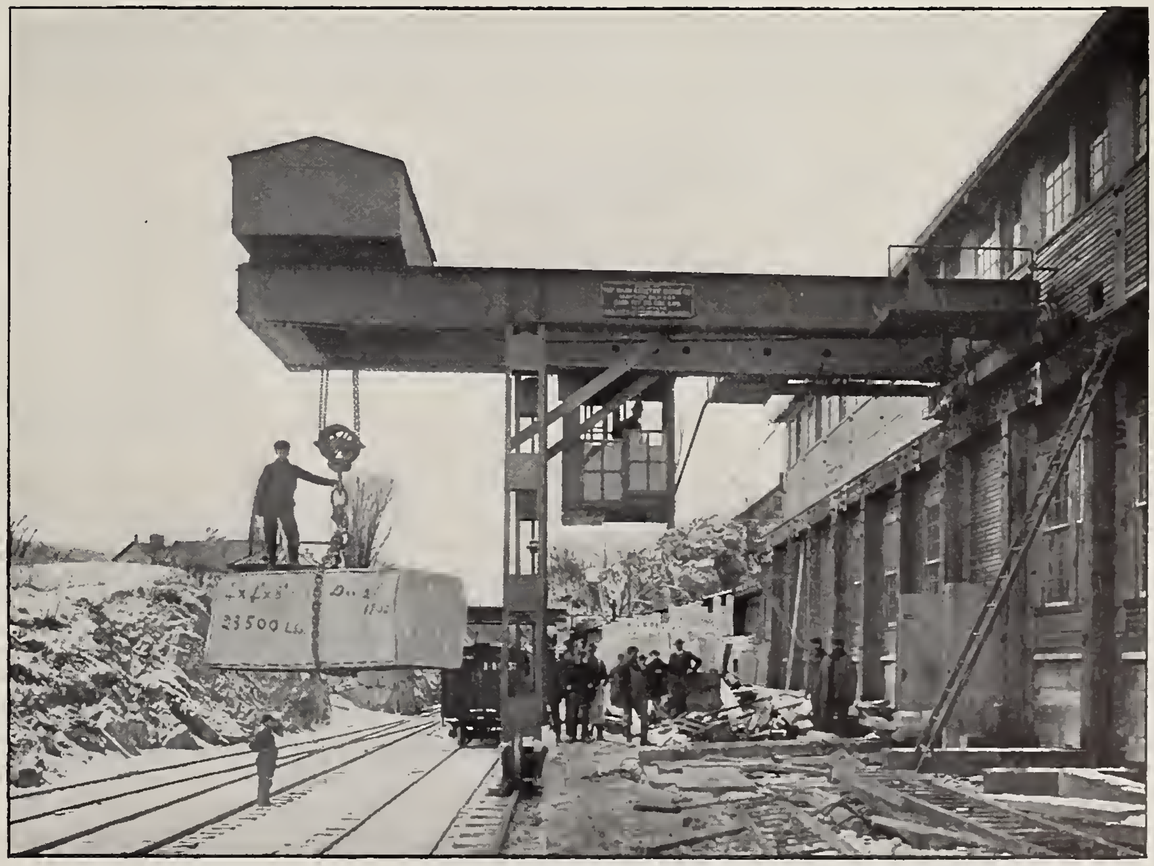
A 30-TON ELECTRIC GANTRY CRANE IN ONE OF THE MARBLE STORAGE YARDS AT WEST RUTLAND, VT. MADE BY THE WHITING FOUNDRY EQUIPMENT CO., HARVEY, ILLINOIS

of 150 feet, the penstock being 9 feet in diameter and 400 feet in length. Two wheels will distribute power to the Proctor plant exclusively, one operating a rope transmission system by which power will be conveyed directly to the sawing machinery and surfacers.

A second wheel will supply the works at West Rutland. It will drive a 750-kilowatt alternator, delivering a 3500-volt current, which will be stepped up to 10,000 volts. This will be sufficient to operate all of the West Rutland apparatus. The third wheel will be direct-connected to a 500-kilowatt alternating generator and to one direct-current generator of 250 kilowatts. The latter will be utilized for lighting as well as power purposes, while the former will be employed for power exclusively. As the plant at Center Rutland will be operated by its own power supply, nearly 3500 horsepower will be secured from this comparatively small volume of water when the improvements are completed.

The Telephone in the Orient

THE telephone has been used in the Orient for a number of years in a perfunctory manner, but it is only recently that its general use has been taken up in India and other Asiatic countries. It is quite probable, says "The American Telephone Journal," that with the tremendous population, averaging in the neighborhood of 400,000,000, not over 15,000 to 25,000 telephones are in use. In Egypt, the telephone system was erected by the Oriental Telephone Company and sub-licensed to the Egyptian Government for a term of twenty-five years. In all, there are



A 15-TON HALF-GANTRY CRANE, AT PROCTOR, VT., INSTALLED BY THE SHAW ELECTRIC CRANE CO., MUSKEGON, MICH.

upwards of 3500 miles of telephone lines, and exchanges have been established from Alexandria, on the Mediterranean, up to Assoum, on the Nile, including the city of Cairo.

In the Strait Settlements, the Oriental Company, which apparently has a monopoly of the telephone field in the East, has secured a franchise for thirty-one years from the Indian Government. In the cities of Calcutta, Bombay, Madras, Rangoon, Moulmien, Singapore and Hong Kong underground cables are to be run within the next four years, in accordance with an agreement made with the several governments. The license for operating in India proper was granted for a period of sixty years, on account of the large amount of work to be done and the tremendous outlay involved.

A trouble that has confronted all propositions involving labor is the caste question. The Hindoos are divided into numerous sects, each sect of which owes allegiance to a certain god. For instance, there are Brahmins, who worship Brahma, devotees of Vishnu, Parsees who worship fire, and Mohammedans. According to the ancestry of these various people so is their caste standardized, and we find that the average Indian household requires from two to twenty different servants. A man who draws water and is called "Bishi" would not dare to dig the garden for fear of losing caste. The man who operates the long swinging fans—called "punkas"—and who is termed a "punka-walla," would not fetch the mail or cook the dinner.

The lowest class are the "Majoors," who dig the streets and are equivalent to the ordinary laborer in the United States. The wages these people receive vary from 6 to 20 rupees, or, in American money, from $2 to $7 a month. Low as this may seem, it compares favorably with the wages paid for coolies and other Oriental labor.

In China, further says "The American Telephone Journal," telephone exchanges have been in operation for a number of years in the cities of Canton, Hong Kong, Shanghai and Pekin. These systems employ Swedish apparatus almost exclusively, whereas in India the apparatus is German, French and English. In Japan telephone development has been of a most rapid character. In fact, nearly all the large towns have telephone systems. At present English apparatus is used exclusively, but it will soon be replaced by the American type of instruments. The Japanese are particularly adapted to the rapid assimilation of American ideas, and their telephone systems would compare favorably with many of the smaller ones in the United States.

The construction of the aerial lines in Oriental countries necessitates precautions not met with in European or American construction. For instance, long stretches of lines run through country districts and dense forests, where the trees and shrubs grow so rapidly and are so dense as to necessitate a constant vigil to protect the line from being short-circuited or grounded by the trailing creepers. Again, wild animals do their share of destruction, and it has been found necessary to use iron poles in many instances.

A recent shipment by an American firm was made of 40,000 composite poles with iron bases and wooden tops. The reason for this composite construction was that the tigers and other wild animals would try to sharpen their claws upon the smooth wooden poles, so that they would soon be worn away. With the iron base and the wooden top the required protection was secured and, at the same time, the cost was considerably reduced.

An Electric Power Era in Scotland

WRITING under recent date from Edinburgh, United States Consul Rufus Fleming says that no trade there has a better prospect at this time than that of the electrical engineering firms. The demand for motors and all other electrical apparatus will undoubtedly continue to grow from month to month, and American companies prepared to compete in these lines of manufacture have now their best opportunity. The applications of electricity as a motive power in various industries, for urban lighting and traction, as light and power for coal mines and other uses, examples of which are numerous, mark the real dawn of the electric-power era in this part of Great Britain.

American manufacturers have in the past few years furnished some of the heavy machinery for municipal generating stations and private plants, and also a considerable number of dynamos, motors, etc. American-English concerns have done much in this line—in fact, they seem to be well ahead of all others. Recent developments mean an expanding market, to which American manufacturers of electrical machinery and supplies may find it profitable to devote earnest attention.

New Sources of Rubber Discovered

A RECENT consular report says that during the past few months . discovery has been made that there are in the interior of Brazil vast forests of trees from which can be produced a high grade of rubber known to the trade as "manicoba."

The area is said to be very large, but cannot be defined, as the region has not been fully explored. The attention called to the first discovery has led to further exploration, with the result that from time to time notice comes of other sections where like trees grow in profusion.

It has also been recently reported that rubber has been found in a supposedly useless weed, growing on the arid plateaus and high mesa lands of the Colorado Mountains.

The newly discovered rubber plant grows at an altitude of from 5000 to 12,000 feet and is hardy enough to stand the severities of a hard winter and the extreme heat of a rainless summer.

Governments Electric Roads in Prussia

IN the Prussian House of Lords recently, the Minister of Public Works said that the State might soon begin the construction of interurban railroads between cities of considerable size, to be worked by electricity at great speed on the open road (38 to 50 miles an hour), but with the cars running over the street railroad at the two termini, and, of course, at low speeds. Frankfort and Wiesbaden were named as places suitable to be connected by such a line. Wiesbaden has about 60,000 inhabitants, and Frankfort 290,000, and they are 26 miles apart.

Tests of various systems of wireless telegraphy are being made at the Navy Yard, New York, according to the "Army and Navy Journal," under the direction of Lieut.-Com. J. L. Jayne, U. S. N. The Bull system has been tested, and its inventors claim for it that it can be adapted to any instrument using a coherer. Other systems to be tried are those of De Forest, Fessenden, Rochefort, Lodge-Muirhead, the Pacific Wireless Telegraph Company and Telefunken. The Pacific Wireless Telegraph system is that now in use by the Treasury Department in Puget Sound, but the Government experts say that it is effective for only 12 miles. The Marconi Company declined to enter the competition. They wrote the Bureau of equipment that they did not believe the test to be thorough enough, likening the contest to a test of ordnance wherein a rifle with an effective range of 3 miles is pitted against one which kills at 80 yards.

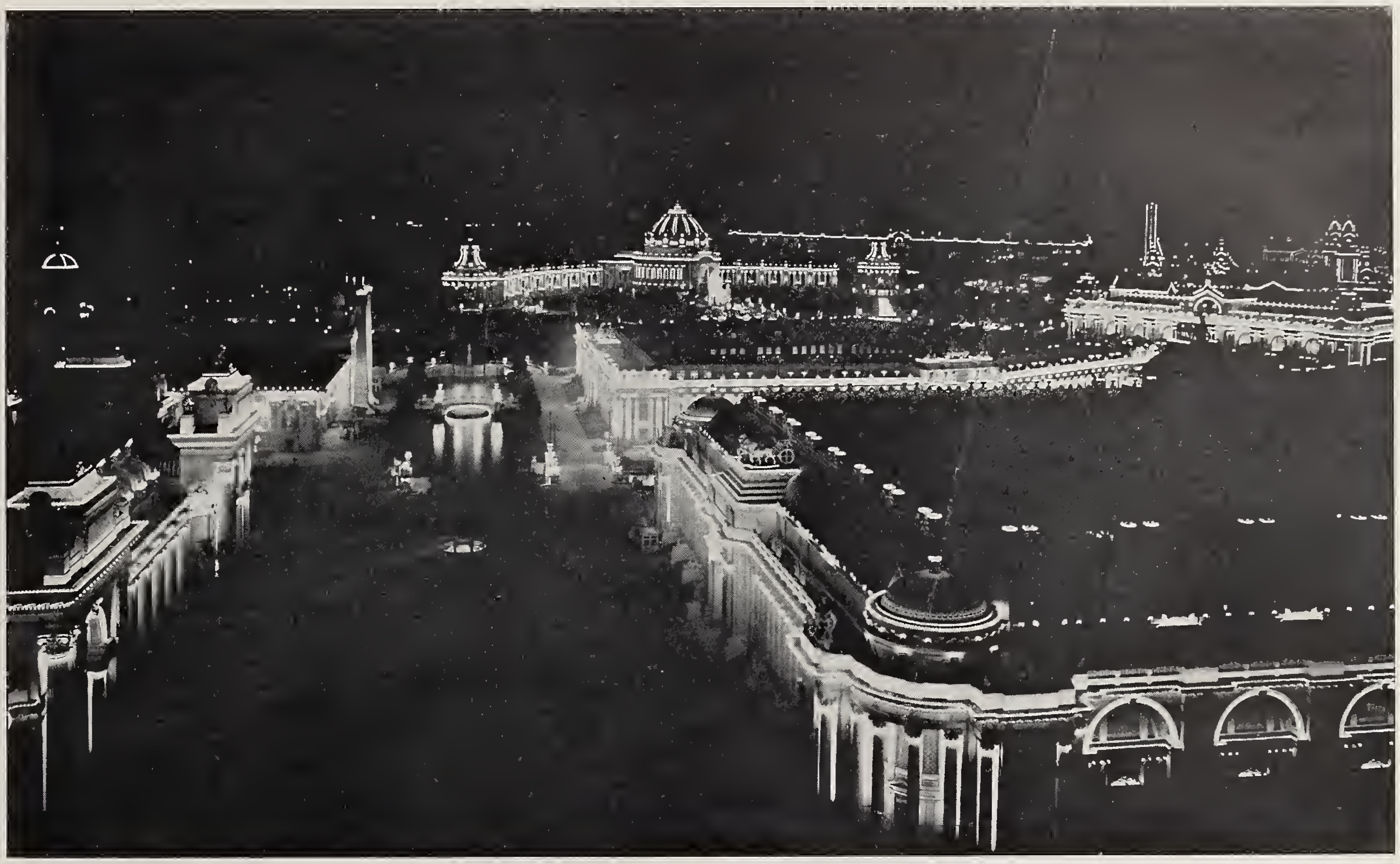
THE ELECTRICAL AGE

Established 1883

Volume XXXIII Number 3
$2.50 a year; 25 cents a copy

New York, September, 1904

Entered at the P. O. as 2d-class matter.



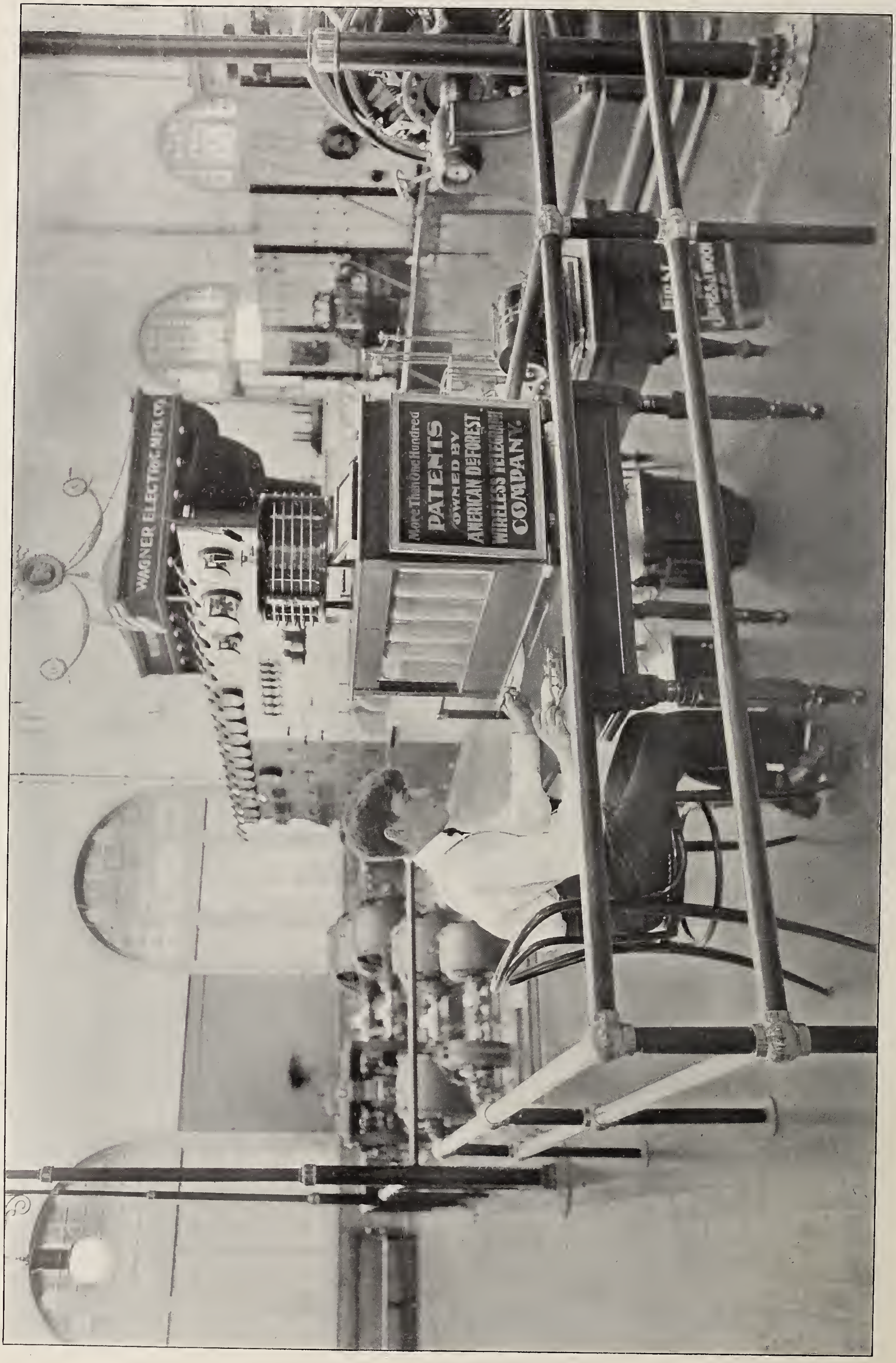
A NIGHT VIEW FROM THE AMERICAN DE FOREST WIRELESS TELEGRAPH OBSERVATION TOWER

Wireless Telegraphy at the St. Louis Exposition

EACH great World's Exposition has been characterized by the presentation of some prominent invention. At the Centennial Exposition the telephone was first presented as a scientific curiosity; Chicago saw the incandescent lamp applied for the first time on an adequate scale for general and ornamental illumination; and the St. Louis Exposition may be similarly characterized as the first to present in an adequate and comprehensive way the new art of wireless telegraphy.

This latest invention is well shown in the exhibit of the De Forest Wireless Telegraph Company, who have on the fair grounds ten operative sets of instruments representing seven separate stations. The De Forest observation tower stands prominently at the entrance to Orleans Plaza, 300 feet in height, and is equipped with two electric elevators. These are in constant operation, and the many visitors to the top of the tower evidence the popular interest in this new art of wireless telegraphy, as well as an appreciation of the opportunity for obtaining a bird's-eye view of the main picture of the fair.

The wireless telegraph station on this tower is on the 100-foot platform, far above the building tops and overlooking Forest Park. The walls of the station are made entirely of glass, and in the distance may be seen the masts of the two downtown newspaper stations, to which the wireless messages are being continually sent. The St. Louis "Post Dispatch" and the St. Louis "Star" receive regular daily news service from this station. From 3000 to 5000 words per day are transmitted at a rate of 25 to 35 words per minute, detailing such World's Fair news as the reporters of the two papers can collect upon the fair grounds. The downtown operators are located in the press or setting-up rooms of the newspapers and hand



SENDING WIRELESS TELEGRAPH MESSAGES FROM THE FORT WAYNE BOOTH IN ELECTRICITY BUILDING AT ST. LOUIS

INTERIOR OF THE DE FOREST WIRELESS TELEGRAPH STATION IN THE OBSERVATION TOWER SHOWN ON PAGE 165

the copy directly over to the typesetter.

On this observation tower the antennæ lead up to a gaff extending from the roof of the tower, a distance of 200 feet. Notwithstanding the fact that the steel structure of this tower does not make it well suited for wireless telegraph transmission, messages have been received from this station as far away as Springfield, Ill.,—a distance of 105 miles. Were this tower of wood, a considerably greater distance could be attained. The wireless tower is covered with incandescent lamps, over 3500 being used in its decoration, and at night it stands out conspicuously, far above all the other buildings, even overtopping the crown of Festival Hall.

The power supplied at the observation tower is direct current at 500 volts. A 70-H. P. motor-generator transforms this voltage to 240, at which pressure the current is supplied to the elevator motors. On the 100-foot platform a 240-volt motor drives by belt a 2-K. W., 60-cycle, 110-volt generator. This latter voltage is used for the wireless telegraph transmitter. The ordinary Morse key of the transmitter breaks up the 60-cycle current into the dots and dashes of the telegraph code so rapidly that a speed of transmission is attained fully equal to any on land wire.

Next in importance are the three De Forest exhibits in the Government Building. Of the seven patents chosen by the United States Patent Office to be represented at the World's Fair, those relating to wireless telegraphy probably command the most popular interest. In the same building the United States Signal Corps has two De Forest sets in operation, and messages may be received from either the observation tower or the Patent Office station.

In the Government Building the power is taken from a 25-cycle current, and as the De Forest coil is of open-cord type it will not operate satisfactorily on this low frequency. A Wagner motor-generator of 1-K. W. capacity is therefore used to transform the current from 25 to 60 cycles, 110 being the voltage in each case.

Visitors to the Electricity Building have their attention drawn to the southwest corner by the sharp and penetrating crackle of the high-frequency, wireless-telegraph spark in the De Forest booth. Here stand the tallest structures in the building, three slender towers of wood, reaching up 75 feet to the eaves of the building, representing, in facsimile, the 225-foot towers which the American De Forest Company are about to erect at Cape Flattery, Wash., for Alaskan and trans-Pacific service.

A DE FOREST WIRELESS TELEGRAPH AUTOMOBILE

From the tops of these three towers depend three screens of fine antennæ, converging at the bottom to the bright helix on top of the transmitting instrument.

All day long the operators at this booth are busy transmitting and receiving messages from the tower of the long-distance station or from the Fort Wayne station in the same building. A very popular test by the public is to write out messages at the station in the Fort Wayne exhibit and, strolling over to the main De Forest booth, find them already written out by the operator there.

Some very interesting work in tuning or syntonic wireless telegraphy, showing the ability of the De Forest system to operate several different transmitters simultaneously without interference, is shown there every day. The receiving operator can, at will, attune his receiver to the messages from the Fort Wayne station, from the observation tower, or from the long-distance station on Art Hill.

In the Electricity Building the 60-cycle current is obtained directly from Machinery Hall. There the 2-K. W. transformer, which is regularly rated for 300-mile transmission over water and 100 miles over land, is exactly similar to that in the observation tower.

But perhaps the most interesting of all the De Forest installations upon the Exposition grounds, especially to the electrician and technical man, is the long-distance station on Art Hill. The tall mast of latticed wood, holding aloft its gigantic cross-arms, 210 feet above the hill, towers far above the white walls of "Old Jerusalem" with its star and crescent.

The ground plate at the long-distance station consists of 140 square feet of copper plate, buried 8 feet directly below the station. Means are provided for maintaining this in a damp condition.

At the Electricity Building, the ground is made to the system of water pipes and, at the wireless observation tower, directly to the frame of the tower itself. This latter arrangement makes the wave length of the antennæ considerably longer than if they were suspended from a wooden structure and the ground were made in the ordinary manner.

The arrangement of antennæ at the long-distance station is interesting. Along the 40-foot cross-arm hangs a horizontal wire from which 20 verticals are suspended. These antennæ average 250 feet in length and are bowed out from the mast to a great distance by means of cord spreaders. The antennæ enter the roof of the building in two sections of 10 wires each. The receiving antennæ are entirely distinct from these. Within the building, which is 20 by 40 feet, the visitor sees only the operating table, the relay keys and the receiving instrument. The large transformer, condensers and other apparatus are placed in a separate room; through a window in the partition, however, one may see the dazzling brilliancy of the

enormous spark which accompanies every signal. This spark has been so successfully muffled as to be scarcely audible outside of the building, but when the doors of the muffler are opened, a roar is heard, reminding one of the cannonading at the Boer war show, nearby.

Messages have already been sent from this station to Springfield, Ill., where the signals are heard in the telephone with a sound, as described by one operator, "like the rattling of stones in a tin pail." Overland service with Chicago and Kansas City awaits only the completion of similar masts at those two cities.

Although the station in the Electricity Building is only a quarter of a mile away from this long-distance station, the operator there, with his receiver connected to the 75-foot antennæ, is entirely unaware of the transmission of messages from this large power station, until he has attuned his instrument carefully to the wave-length of that transmitter. Similarly, at the "Post Dispatch" and the "Star" stations downtown, the operators are receiving press dispatches continually from the observation tower while the long-distance station is transmitting to Springfield. On several occasions two operators, each with a distinct receiving and tuning apparatus, were connected to the same receiving wire downtown, and while one received dispatches from the long-distance station the other operator read messages from the observation tower.

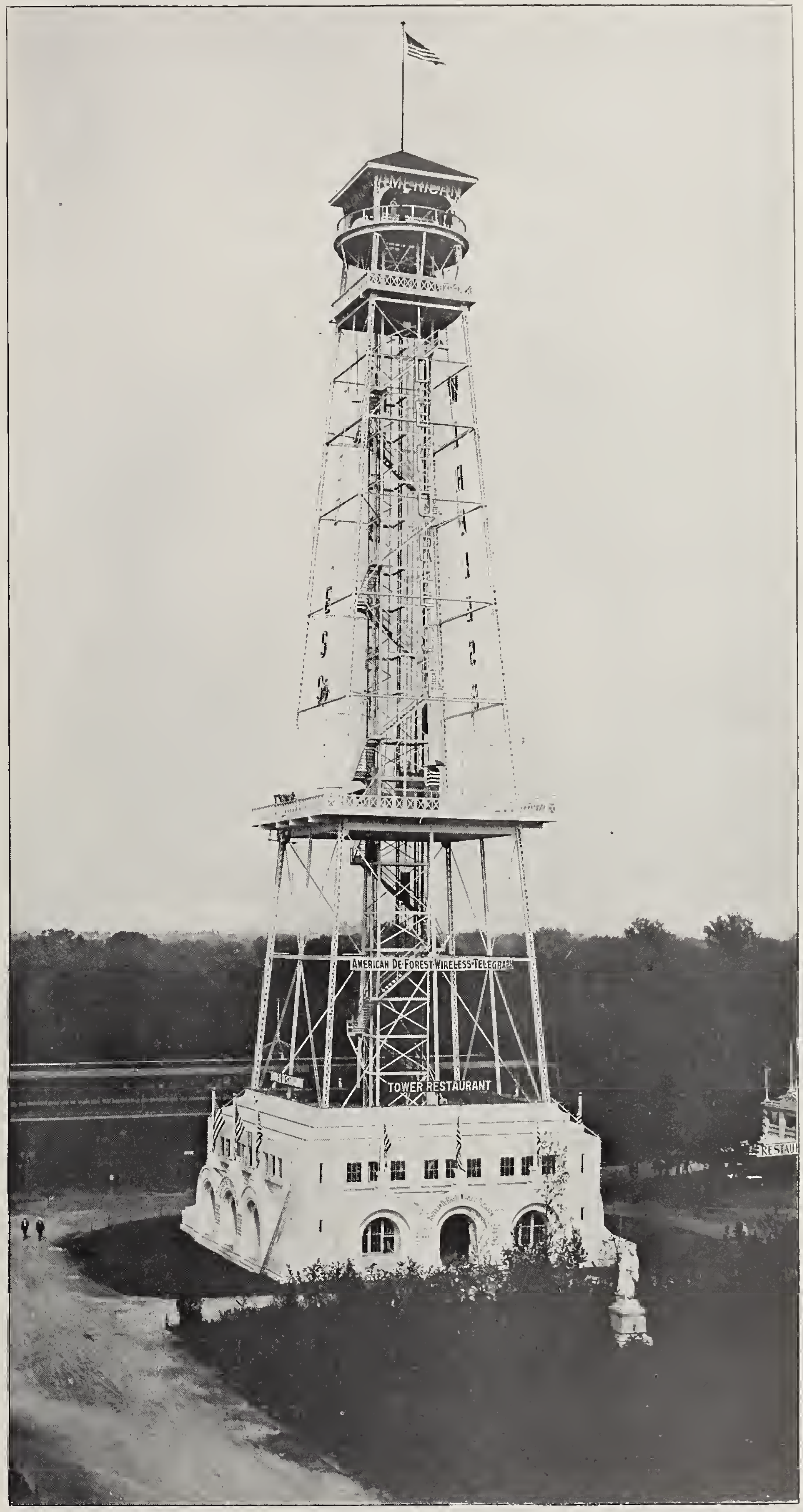
In addition to the foregoing stations, the De Forest Company exhibit in the Transportation and Electricity Buildings their wireless telegraph automobiles, such as they used so successfully in sending stock quotations from the New York curb exchange to the brokers' offices nearby.

Incomes of Technical Graduates

As evidence of the fact that higher education is of value in fitting a young man for his life work, and especially that technical education is necessary if his work be engineering, the "Journal" of the Worcester Polytechnic Institute has prepared statistics showing the success of the Institute's graduates. These statistics are given in an advance sheet of the forthcoming November issue.

A diagram shows the average annual income of the alumni of the Institute, the graduates being from the course of electrical engineering. As this course at the Worcester Polytechnic Institute has been established but eight years, there are data available for this period only, but during this time a large number of students have been graduated, and data have been received from a sufficient number of them to represent conditions fairly.

The curves show that the average graduate, who receives $500 per year for his first position after leaving the Institute, rapidly increases in value, so that, at the end of eight years, he may expect to receive an income of about $1900; or, if he has been a graduate student at the Institute for one year, his income is shown to average



THE DE FOREST WIRELESS TELEGRAPH TOWER, NEARLY 300 FEET HIGH. THE WIRELESS STATION IS ON THE 110-FOOT PLATFORM

THE DE FOREST LONG-DISTANCE STATION ON ART HILL. THE MAST IS 210 FEET HIGH. GOOD FOR 300 MILES OVERLAND SERVICE

about $2500, which, capitalized at 5 per cent., gives him the income on an investment of about $50,000. By investing five years of his time and the cost of his college training, he has after a few years and for the remainder of his life increased his income earning value by not less than $40,000.

British Precautions Against Subway Disasters

THE British Board of Trade has issued the following circular of precautionary standard specifications and instructions to be observed by underground electric railways:

STATIONS AND PERMANENT WAY.

1. Sleepers to be of hard wood, not creosoted, and to be laid in concrete or ballast, and covered with a layer of gravel or finely broken stone free from dust, the ballast to be finished to a level surface, so as to form a convenient roadway for passengers in case of emergency. If ballast is not used, the space between the rails to be covered with granolithic slabs, or slabs of a similar material, to form as wide a roadway as possible for passengers. No timber planks to be used.

2. Tunnels to be provided with lights capable of being turned on from the stations at either end of each section, and, if necessary, at some intermediate points. The lighting circuits to be independent of the traction supply.

3. Separate entrances to and exits from each platform of the stations to be provided, and to be situated as nearly as possible in the middle of the platforms.

4. All stairways, passages and exits from the stations to be conspicuously lighted. Not less than 25 per cent. of the lights in these places to be supplied from the independent source. If necessary, the exits to be made more conspicuous by the use of colored lights, in addition to white lights.

5. Platforms not to be made of wood, and woodwork to be eliminated as far as possible from signal boxes, lifts, offices, etc., below ground.

6. Efficient hydrants, hose and fire prevention appliances to be provided.

7. Ventilating ways to be provided wherever possible from the station and the tunnels to the surface.

THE DE FOREST ST. LOUIS EXPOSITION OBSERVATION TOWER AT NIGHT

EQUIPMENT.

8. Cars to be constructed of metal; woodwork to be reduced to a minimum, and to be non-inflammable. Hardwood to be used in preference to soft. Interior fittings, panels, seats, etc., to be of incombustible material.

9. No main electric cable to be carried through the train, and motors to be placed on the front and rear carriages only. No motor to be situated in the middle of the train.

10. Means to be provided at both ends of every train to enable passengers to alight from the cars in case of emergency. Oil lamps to be carried in every train.

11. India rubber or other inflam-

mable insulating materials to be avoided as much as possible, and the outer covering of cables to be uninflammable material that will not give off smoke.

12. Means to be provided for enabling a driver at any part of the tunnel to put himself into telephonic communication with the adjacent stations.

According to "The Railroad Gazette," this circular embodies the recommendations which have been made from time to time by Mr. Geo. Westinghouse, as to precautions necessary for the safe operation of electric trains.

The Board of Trade takes a decided stand on the use of multiple unit control in section 9 of its report. The current required by a train of several cars is sufficient, if short-circuited, to melt a good-sized section of iron or steel and set fire to the woodwork about the car, roadbed or stations.

As is well known, in the multiple unit system, each car takes up only enough power for its own operation, thus eliminating the use of a main electric cable passing beneath the entire train. The regulation prohibiting motor cars in the middle of the train will make necessary some changes in the make-up of trains on several of the London underground roads. The Great Northern and City line now runs seven-car trains consisting of three motor cars and four trailers. Each motor car has 250 H. P. in motors, so that if seven-car trains are still run, the use of but two motor cars, one at the head and one at the rear of the train, will cut down the power available for acceleration by 33 1-3 per cent.

High acceleration is one of the important features of electric traction, and where stops are frequent the average speed of a trip is dependent on the acceleration obtained on leaving stations. Of course, an underground road's acceleration is not so important as on surface or elevated roads, because the number of stops is not so large. The Central London Underground Railway runs six-car trains, including a motor car at each end of the train, but this arrangement of cars was made necessary because the tunnel is not high enough for cars having motors beneath the floor. The motor cars used are of special construction, the floor being raised over the trucks which carry the motors. In case of fire the use of a motor car at each end of a train is, of course, an element of safety, as the burning motor can be quickly uncoupled from the train, but with the precautions taken to make the cars incombustible it is quite possible that this provision is unnecessary.

The full statement of precautionary rules and measures for the New York subway has not yet been made public, but, leaving out of the discussion the arrangement of motor cars, the New York requirements, according to "The Railroad Gazette, will be in every respect equal, if not superior, to those laid down by the British Board of Trade. For example, all the lighting in the New York subway is to be done by circuits independent of the power circuit, while the British requirements provide only that "not less than 25 per cent. of the lights" be supplied from independent sources. The New York signal system is the best that human skill can provide, and the steel cars, designed to supersede the experimental cars now in use on the elevated, are as nearly incombustible as possible.

Safety Device for the Berlin Rapid Transit System

THE Berlin Elevated and Underground Electric Railway has installed in the motorman's compartment a short-circuited switch, so that the current in the third rail may be earthed and the fuses blown at the power station, thus rendering the section dead. An alternative means of short-circuiting is afforded by a portable bar which is provided with insulating brushes of some length, and which can be placed by the motorman across the third and return rails.

These devices are intended for use only in the tunnel sections of the railway, if it should be necessary for passengers to alight from a train and proceed to the next station, or to escape shafts between the stations. The tunnels are now lighted from two independent circuits at intervals of 52 feet, and fire extinguishers are located in them at intervals of 325 feet.

The hydrants and sand boxes at the stations have been doubled, and each station is directly connected with the fire brigade by means of an alarm wire. In addition to these arrangements the cars are equipped with portable sand boxes and with other fire extinguishing appliances using water.

An improved telephone service meter, invented by J. L. McQuarrie, and assigned to the Western Electric Company, Chicago, provides for the automatic recording of the number of telephone messages of a subscriber. After the prearranged number of messages have been exhausted, the meter registers the excess and notifies the central office.

Magnets for Eye Surgery

IN the remarks in these columns quite recently relative to the lifting power of magnets, allusion was made to the fact that one of the uses to which the lifting power of the magnet is put is that of withdrawing small pieces of iron from the human eye. It is possible that some readers may have thought this application was more fanciful than real; but quite recently Dr. C. S. Bull has reported the case of a man who was struck in the eye by a flying piece of steel, which perforated the cornea, iris, and lens and entered the vitreous body, which became filled with blood. Dr. Bull decided to make an attempt to extract the metal by means of a powerful magnet. After bringing the magnet almost into contact with the eye, a piece of steel about 0.156 inch long and 0.136 inch wide was drawn out of the eye and adhered to the magnet. In ten days the man was discharged with vision about two-thirds normal.

The Telegraph in Persia

AN important event in Central Persia was the arrival of the telegraph line at Kerman. When complete it will connect direct with India. It is believed that the benefits of the extension of the line will be immense. In the east, brigandage will be reduced by the prompt notice that can be given along the line, while the long-disused caravan routes between Southern Persia and India will again be brought into use. Baluchistan will also be a great gainer by the new state of affairs.

The line is expected to be complete by the end of this summer, and the work is regarded as a triumph for the four Englishmen who are in charge of the 200 Persian and Indian workers. The cost of the line works out at about $650 per mile.

When, rather over a year ago, a community of interests was effected for a period of thirty-five years between the Edison and Thomson-Houston interests in Germany, represented by the Allgemeine Company and the Berlin Union Electric Company, respectively, it was reported that an entire fusion might take place. This has now been realized, the Allgemeine Company increasing its capital to four and a half millions so as to acquire the Union Company's interest. Already 95 per cent. of the latter's shares have been transferred to the Allgemeine Company, and the absorption will soon be completed.

Electrical Progress in Canada

By GEORGE JOHNSON, Statistician of the Dominion of Canada

THE 24th of May, 1904, was the sixtieth anniversary of the sending of the first Morse message over a telegraph wire. Without entering into the controversy which has sprung up as to the reality of the claims that have been made for other persons, the fact that messages were sent on that date sufficiently differentiates the month of May, 1844, to fit it to become a starting point in an estimate of the development of electricity as a factor in modern civilization.

There are now throughout the world over one million miles of telegraph line and over four million miles of wire. These represent an outlay of capital equal to 500 million dollars. The outlay for cables will increase the total capital invested to 850 million dollars.

Over head and under seas there is a daily transmission of 1,500,000 telegrams and 36,000 cable messages, the yearly totals being 557,000,000 land messages and 13,100,000 cables in 1903.

This is the minimum, for in South Africa (for instance) there are thousands of miles of line which are in the hands of companies that are not required to make returns. Another fact that has to be taken into consideration is that these figures do not include the telegrams sent by railways in the management of their own business. These number many millions a year. Thus, Russia, in 1902, included the telegrams despatched hither and thither over her 37,000 miles of railway, and the result was a total of 101,639,542 telegrams, whereas in the year before (1901), when railway telegrams were not included, the messages sent numbered only 20,000,000.

A third fact ought to be kept in mind. In many countries, Canada, for instance, the press messages are not included in the number reported. Everyone knows the important part the newspaper telegraph service plays in a country of magnificent distances such as Canada, where for the months during which the Federal Parliament sits, the whole country is absolutely dependent upon the daily telegraphed report for a knowledge of the proceedings. Divided by ten to represent an ordinary message, the millions of words of press "flimsy" would far exceed the other messages sent and delivered in the course of the year, and representing the business, the social and the other activities of the country employing the telegram as a medium of communication.

No estimate can be made of the number of these messages. It is plain, however, that at least 1,500,000 messages pass to and fro every day of the 365 days of the year. All this immense business can be traced to that beginning in May, 1844, when the Morse system turned the plaything of science into an instrument of practical world-wide, every-day use.

The countries which most use the telegraphic mode of communication are the British Empire, the United States of America, Germany, France and Austria-Hungary.

The British Empire has over 218,000 miles of line and nearly 1,000,000 miles of wire and sends and receives 127,000,000 messages a year.

The United Kingdom despatches and receives about 92,500,000 messages, or 222 per 100 of her population. Her daughters follow her example. Australia goes beyond her, sending 223 per 100 of the population.

New Zealand, the wonderful sister under the Southern Cross, goes far beyond mother, sisters, cousins, aunts or any other relative or stranger country in the world, topping the list with 550 telegrams* per 100 of her population, Maories included.

Canada in 1903 had 36,780 miles of line and 96,728 miles of wire, and her record is 5,313,800 messages, or just about 1 message for every man, woman and child on her broad acreage. In the matter of miles of wire Canada somewhat exceeds the United States, having 18,250 miles per million inhabitants against the United States equipment of about 13,000 miles per million.

The African possessions of the British Empire, notwithstanding that only a comparatively small proportion of the messages sent are included in the available statistics, have a record of 7,555,000 messages, or 108 per each 100 of their population.

Table I. gives as complete a list of countries and telegraphic statistics as the writer has been able to compile.

* In New Zealand the number of telegrams forwarded in the year ended March 31, 1904, was 4,671,904, an increase of 9.38 per cent over the number for the year 1903.

ELECTRIC PROPULSION.

It is about sixteen years since the scientific practicability of propulsion by means of electricity was demonstrated.

In the United States there are about eleven hundred street railway systems. (The United States Census returns give 871 street railways, chiefly electric, for 1900). There are 25,800 miles of track; the capitalization is $1,630,000,000 and the funded debt $1,275,000,000. The earnings were over $240,000,000 last year, between $600,000 and $700,000 a day.

The United States have made great progress. They have 322 miles of electric railway to each million of the population of Continental United States. These carried between 5,000,000,000 and 6,000,000,000 persons, or about sixty-five times the population, and about eight times as many as the steam-driven railways carried. Canada's electric railways carried last year 167,704,000 passengers, or about thirty-one times the population of the Dominion.

When it is recalled that the urban population of the United States forms over 37 per cent. of the whole, while Canada's urban population is only 26 per cent., it is evident that the electric railways of the Dominion are doing well and give promise of doing better; as Canada's urban population, following the continent's trend, increases its proportion, Canada's electric railways carried, like those of the United States, about eight times as many passengers as her steam-driven railways.

Ottawa claims to be the first city in Canada to adopt electricity as the motive power of street railways, the Ottawa Electric Railway Company beginning its career in July, 1891. The development in Canada is, therefore, all within twelve years. That of the United States began in 1888, when there were under 100 miles of electric railway in the country.

Table II. on the next page gives particulars of the Canadian electric railway companies for the years ended December 1, 1901-1903.

The following is the distribution by

provinces of the electric railway mileage in 1903:—

	Single Track	Double Track
Ontario	273.14	87.64
Quebec	96.09	82.57
British Columbia	41.75	6.25
New Brunswick	10.06	2.50
Nova Scotia	23.71	1.58
Manitoba	10.00	12.00
Total	454.75	192.54

TELEPHONES

The summer of 1904 was the thirtieth anniversary of the invention of the telephone. In 1874, Mr. Graham Bell, then on a visit to his parents, who lived in Brantford, made some laboratory experiments which proved that speech could be transmitted by wire. Two years later, August, 1876, the first transmission of speech over a telegraph wire took place in Brantford. In 1877 the telephone went into commercial use, the city of Hamilton being the first to establish it.

From that beginning the use of the telephone has been constantly on the increase. The first returns the Statistical Office secured showed that in 1883 Canada's equipment was 44,000 miles of wire; 33,500 instruments, by means of which 72,500,000 messages were sent in the year. In the ten years since, the number of instruments has increased to 81,500 and of messages to 253,970,000, an increase of 144 per cent. in instruments and of 250 per cent. in number of messages.

Taking the population of the last census there is in Canada one telephone instrument to every 65 persons.

Provinces	Number Persons to One Telephone
Ontario	57.9
Quebec	63.8
Nova Scotia	99.4
New Brunswick	85.3
P. E. Island	215.0
Manitoba	51.5
N. W. Territories	251.3
British Columbia	33.4

There were on the first day of this year fifty-six companies in Canada, divided by provinces as follows:—

Twenty in Quebec, eleven in Ontario, seven in New Brunswick, six in Nova Scotia, one in P. E. Island, two in Manitoba, three in the Northwest Territories, one of these being in the Yukon, and six in British Columbia —the Bell Telephone Company being counted three times, one in Quebec, one in Ontario, and one in Manitoba. Actually there are fifty-three, and we obtained this year returns from all but seven.

Some of them are under the control of the Bell Telephone Company and their returns are included in that company's returns.

The United States in 1900 showed a per capita of one telephone in forty, while in some places, such as San Francisco, it had reached one in twelve (U. S. Census Bulletin). The latest statistics indicate a per capita of one in thirty-eight. This rate of progress is exceeded by Denmark, in which country the per capita is one in every fourteen. Canada has not used the telephone to the same extent, but we appear to be making great strides

TABLE I.—TELEGRAPH STATISTICS.

Countries	Year	Miles of Line	Miles of Wire	No. of Messages	No. of Offices	No. of Messages per Head of Population
Great Britain	1903	49,450	480,400	92,471,000	12,129	2.22
Australia	1902	45,343	121,818	8,431,372	3,102	2.23
New Zealand	1902	7,749	22,672	4,713,351	1,103	6.10
India and other Asian Possessions	1902	57,495	190,887	6,749,372	2,006	.02
African Possessions*	1902	17,885	38,832	7,555,500	......	1.08
Canada	1903	36,780	96,728	5,313,800	3,004	....
Newfoundland and B. W. Indies	1902	3,308	15,187	1,654,000	300	.92
Gibraltar and Malta	1902	67	......	33,500	......	.15
Total British Empire		218,077	966,524	126,921,895	21,644	....
Abyssinia	1902	1,056	3,168	158,400	......	....
Austria-Hungary	1902	39,372	198,303	31,554,715	9,228	.69
Argentina	1902	29,397	58,656	7,000,000	520	1.46
Belgium	1902	4,047	21,874	14,252,100	1,372	2.07
Bolivia	1902	2,465	8,625	1,075,000	68	.47
Bosnia	1902	1,803	4,873	427,452	134	.25
Brazil	1900	14,710	27,720	1,505,042	1,003	.10
Chili	1902	11,060	68,710	4,879,719	608	1.57
China	1902	14,000	49,000	3,430,000	250	.01
Colombia	1898	8,600	25,800	600,000	448	.15
Congo Free State	1902	888	3,108	62,160	40	....
Costa Rica	1902	840	2,940	284,532	68	.92
Cuba	1902	2,300	3,450	430,125	153	.27
Denmark	1902	2,385	8,855	2,409,365	169	.98
Ecuador	1902	1,242	4,347	434,470	60	.31
France	....	90,592	340,180	47,280,070	13,527	1.21
Colonies and Dependencies:						
Algeria	1901	6,520	18,240	2,369,456	539	.50
Tunis	1901	2,420	5,500	978,000	122	.51
Other possessions	....	10,700	32,100	1,605,000	300	.40
Germany	1902	83,526	309,644	45,216,963	25,621	.80
Greece	1901	3,830	5,590	1,205,095	241	.50
Guatamala	1901	3,490	10,470	929,619	157	.59
Honduras	1902	2,825	8,475	618,000	168	1.05
Italy	1901	28,472	107,810	11,682,366	6,078	.36
Japan	1903	†16,128	78,710	18,073,407	2,197	.38
Korea	1902	2,170	6,510	325,500	325	.06
Luxemburg	1902	656	1,390	87,300	196	.37
Mexico	1901	43,675	......	2,665,998	377	.19
Montenegro	1902	343	427	29,590	21	.13
Netherlands	1903	4,010	16,158	5,728,222	761	1.08
Colonies, East Indies	1901	7,518	22,554	729,316	389	.02
Nicaragua	1901	2,440	7,320	140,640	119	.28
Paraguay	1901	500	1,500	97,014	75	.15
Persia	1901	5,480	8,270	16,540	112	.002
Peru	1903	3,220	......	152,808	48	.03
Portugal	1902	5,301	11,688	4,054,230	461	.73
Portugal—Colonies of	1903	2,368	7,104	142,080	80	.01
Rumania	1902	4,350	8,780	2,318,683	1,866	.12
Russia	1902	106,417	325,978	‡101,639,542	......	.15
Salvador	1902	1,920	5,760	715,084	135	.71
Santo Domingo	1902	430	1,290	40,000	65	.07
Servia	1902	2,300	4,925	1,092,527	145	.44
Siam	1902	2,900	7,700	154,000	360	.02
Spain	1901	20,170	47,470	4,627,713	1,534	.25
Sweden	1901	10,077	31,695	2,813,830	2,175	.55
Norway	1902	9,978	53,813	2,278,639	974	1.01
Switzerland	1902	5,556	23,765	3,273,784	2,137	.99
Turkey	1902	25,100	39,800	4,976,070	907	.21
Egypt	1903	2,562	10,868	†1,617,946	544	.16
United States §	1903	196,115	1,029,983	91,391,443	23,567	1.20
Hawaii	1903	250	750	37,500	40	.24
Porto Rico	1903	470	1,410	70,400	70	.07
Philippine Islands	1903	720	2.160	43,200	42	.005
Uruguay	1901	4,604	13,812	397,493	101	.04
Total foreign countries		854,268	3,099,028	430,118,178	100,697	....
Grand total		1,072,345	4,065,552	557,040,073	122,341	

* The statistics for Africa are very incomplete, many thousands of miles of line being in the hands of companies making no returns.

† Not including State telegrams.

‡ Russia including railway telegrams, which numbered 91,639,542.

§ These are statistics of the Western Union Telegraph Company, and include their Canadian ownings. Other minor lines in the United States will bring up the figures to those given above.

TABLE II.

	1903.	1902.	1901.	1900.
Total number of railways sending returns	46	44	43	35
" miles of track, single	454.75	421.39	376.35	......
" miles of track, double	192.54	188.09	179.10	......
" motor cars	2,053	1,895	1,853	1,379
" trailers	298	326	302	......
" snow-sweepers and ploughs	109	97	85	69
" miles run	39,721,153	36,711,130	34,547,975	28,547,908
" passengers carried	167,703,958	145,609,993	132,885,258	94,616,344
" employees	7,439	5,427	5,443	......
Total amount of capital paid up	$29,838,326	$25,961,254	$24,734,040	$18,309,876
" bonded debts	17,013,758	15,794,408	14,166,225	10,454,452
" gross earnings	7.777,324	6.865,907	6,283,666	......
" gross expenses	5,018,779	4,140,490	3,699,283	......

forward, and British Columbia has come within measurable distance of the greatest of telephone-using peoples, the people of Stockholm, in which city there is one telephone to every eight persons.

The Dominion began to construct telephone lines with a commercial end in view, in 1877, as already stated. As far as somewhat incomplete statistics show, fourteen telephone companies now in operation began distributing "hellos" in the decade 1880-1889; fourteen in 1890-1899 and thirteen in the present decade. Of the remainder there is no record. The usefulness of the telephone in business in rural communities is well illustrated by the practice in the great fruit-growing valley of Nova Scotia. The steamer of Halifax is loaded up with all she purposes carrying of other articles. She is to sail on a Saturday afternoon for Liverpool. Her agent telephones to Kentville and Wolfville on Thursday that there is space left for, say, 2000 barrels of apples. Kentville and Wolfville telephone to the sub-agents of the London (Eng.) fruit dealers, "How many barrels can you send to Halifax?" These sub-agents jump into their gigs and in an hour have arranged with the orchardists as to the number of barrels to be delivered on Friday evening at each station along the railway. Then they telephone the result to head stations. Cars are provided in accordance. The fruit is shipped to Halifax Friday night, put on board the steamer the next morning and off goes the steamer, the fruit having been exposed to high temperature hardly at all, the orchardists having had ample time to get their barrels repacked, the railway full opportunity to supply the necessary cars and the steamer being able to take on board the freight without exposing it to the influence of adverse conditions of weather on the wharf.

The number of telephone messages per annum for different countries is:—

France	187,002,352
Germany	766,226,337
Great Britain and Ireland	723,246,368
Austria-Hungary	147,543,138
Denmark	59,210,855
Belgium	38,753,367
Switzerland	26,670,381
Netherlands	31,460,979
Norway	1,723,347
United States	3,002,000,000

ELECTRIC LIGHT, HEAT AND POWER COMPANIES IN CANADA

The equipment of electric light, heat and power companies with which Canada has provided herself is of comparatively recent date. No mention is made in the Census of 1881 of the industrial employment of electricity. In the Census of 1891 the following information is given:—

Establishments	80
Employees	763
Capital	$4,113,771
Wages	297,684
Output	1,154,149

The Census of 1901 limited the inquiry as to manufacturing to establishments having five hands and over, smaller industrial establishments being ignored. This limitation renders the Census of 1901 useless either for comparison with the previous census or as a guide to the equipment of the country in respect to any special industry such as electrical applications. In the preparation of the Statistical Year Book for 1903 an effort was made to procure such data as would give the student a practical and useful idea of the development of the application of electricity to the production of light, heat and power in 1903, with the following results:—

Establishments	316
Employees	1,786
Capital	$20,000,000
Wages	896,215
Output	4,809,227

These figures show a large increase in the twelve years:—Of establishments, 236; of employees, 1023; of capital, $15,886,229; of wages paid, $598,531; and of output, $3,655,078.

The following are the returns of 1891 and 1901 for establishments employing five hands and over:—

ELECTRIC LIGHTS, ETC.

	1891	1901
Establishments	23	58
Employees	630	899
Capital	$3,185,257	$11,891,025
Wages	237,348	451,047
Output	845,134	2,008,017

Expressed in percentages, the increases are:—Establishments, 121 per cent.; employees, 43 per cent.; capital, 273 per cent.; wages, 90 per cent., and output, 137 per cent. In 1891 the yearly wages of the employees averaged $376.75; in 1901, $501. The annual output per employee in 1891 was $1342, and in 1901, $2234.

The percentage of output to capital in 1891 was 26 per cent. and in 1901, 17 per cent. The wages increased 33 1-3 per cent., and the efficiency of the workers, judged by output per employee, increased 66 per cent.

The development in the several provinces, taking the returns of 1891 and of 1903, as seen in the number of establishments of all sizes, is as follows:—

Provinces	1891	1903
British Columbia	2	17
Manitoba	2	7
New Brunswick	7	13
Nova Scotia	7	22
Ontario	48	199
P. E. Island	2	3
Quebec	9	49
Territories	2	6
	80	316

The great province of Ontario, which in 1891 had 60 per cent. of all these establishments, had 63 per cent. in 1903. The other provinces have made evident progress. In the province of Ontario in 1903 about 100 of the plants were found to be using coal or wood, about 60 using water power, and 35 steam and water, the remainder not stating the particulars. In Quebec Province 6 establishments reported using coal or wood, 38 utilized the water power of the province and 7 combined water power and steam power. In New Brunswick 11 obtained power from coal or wood and 2 from water. In Nova Scotia 16 used coal and 6 water; in Prince Edwards Island, 2 coal and 1 water; in Manitoba, 5 coal and 2 water, with steam as an occasional auxiliary. In the Territories, except in the Province of Quebec, the majority of the plants use coal or wood; sometimes sawdust is utilized.

Some of these electric plants have been absorbed by others, so that the 316 plants really represent 324 different places lighted by means of electricity. These in 1903 had 14,780 arc lights and 1,212,861 incandescent lights. Taking the arc as equal to ten incandescent lights, the country had on June 30 last 1,360,661 lights in use. This is an increase of 236,865 lights in twelve months, or over 21 per cent. Where there were five lights in 1902 there were six in 1903. The growth since 1898 has been:—Establishments, 1903, 324, an increase of 65. Arc lights, 14,780; increase, 4391. Incandescents, 1,212,861; an increase of 749,246, showing an increase of 42 per cent. in the number of arc lights and of 161.6 per cent. in the incandescents.

Of the Provinces, Ontario is far away the chief employer of the electric light. This Province had 203 of the 324 plants in use in the Dominion. It has considerably more than one-half the total number of arc lights, and 47 in each 100 of the incandescents. Thirty-four municipalities in the province supply themselves with electric lighting.

The Province of Quebec has 53 plants, 3853 arc lights and 409,503 incandescents. It is, therefore, behind Ontario by 4571 arcs and 158,990 incandescents. It has made, however, greater proportionate gain since 1898 than Ontario, the gain in arcs being: —Ontario, 36.2 per cent.; Quebec, 47.6 per cent.; and in incandescents, Ontario, 138.6 per cent., and Quebec, 212.3 per cent. During the period 1898-1903 the number of plants in Quebec increased by 13.

The largest single plant in the Dominion is that of Toronto, with its 170,000 lamps, arcs being taken as each equal to 10 incandescents. The next largest is that of the Lachine Rapids Hydraulic & Land Company,

Montreal, 158,503. The third in size is the Ottawa Electric Company, with 111,927 lights.

The other Provinces have made considerable progress. To the west, Manitoba has in 1898-1903 increased its arc lights from 162 to 375 and its incandescents from 13,800 to 31,905.

The Northwest Territories have not increased as rapidly as the other parts of the Dominion, their arcs numbering 29, an increase of 4 in the period named, and their incandescents numbering 6677, an increase of 1997.

British Columbia shows the largest proportionate increase of any of the divisions of Canada, its increase of arcs being 377, or 82 per cent., and of incandescents 74,297, or 257 per cent. In 1898, British Columbia and Nova Scotia had almost the same number, British Columbia having 7 more arcs and 169 more incandescents; yet Nova Scotia has increased the number of its incandescents by 32,140, or 11.16 per cent. The three Maritime Provinces had in 1898, 951 arc lights and 46,977 incandescents, and in 1903 they had 1267 arcs and 93,120 incandescents, an increase of 33 1-3 per cent. for arcs and of over 98 per cent. for incandescents.

In the manufacture of electrical appliances and supplies considerable progress has been made.

Table III. gives particulars of establishments having five hands and over.

TABLE III.—ELECTRICAL APPLIANCES

	1891	1901
Establishments	13	25
Capital	$1,520,000	$5,267,397
Hands	408	1,922
Wages	$158,500	$846,618
Output	801,752	3,032,252

In addition, the census of 1891 gave as follows, for establishments with under five hands:—

Establishments	10
Capital	$43,813
Hands	17
Wages	$14,615
Output	63,100

It will be a safe estimate to give the smaller establishments of 1901 an increase somewhat greater than that of the larger ones, which is about 250 per cent., say a total output of $3,250,000 for 1901. for both large and small establishments.

In addition, the imports of Canada have increased very considerably and attest, like the home manufacturing, the vigorous development of electricity as the harnessed servant of humanity.

Of electric arc lights and carbons and carbon points, Canada imported during the past fourteen years an average of $35,000 worth a year. The imports for 1902 and 1903 averaged $1,090,050 a year and the imports for the year ended June 30, 1904, were $2,406,912.

In detail the imports of Canada for the last fiscal year were:—Electric light carbons over 6 inches in circumference, $62,794; all other electric light carbons, $25,985; electric motors, generators, dynamos and sockets, $488,944; electrical apparatus, insulators, electric and galvanic batteries, telegraph and telephone instruments, $1,829,189; a total of $2,406,912.

It may also be mentioned incidentally that of this total, $2,332,899 were imported from the United States of America.

It appears that the outlook for Canada is one that shows the country going forward by leaps and bounds in its application of electricity. Electricity will drive the carriages on the King's highway as well as those on the iron way. It will do her plowing, sowing and reaping. It will make trolley parks an important part of the national equipment for recreation. If it does not help into this life it will help some one out of it, by order of justice.

It will do the nation's smelting and welding. It will supply from peat bogs fuel for Ontario and Quebec. In the form of the "wireless" it will make travel by sea along her coasts and estuaries as safe as travel about the streets of the towns. It will make hats, cook dinners and warm toes. It will become so tamed to service that it will, with the message, present a photograph of the speaker, and cut out in one town a cheque on a bank written hundreds of miles away, and do it so well that the original will be destroyed and the transmitted cheque remain the only existing original. Already twelve messages have been sent over the one wire. How many more, who can say?

There is in use a telegraph-telephone system by which Canadian railways can employ the same wire for both simultaneously. Her surgeons use it to minister to mind and body diseased. Her warriors use it, in the form of the wireless, to transmit orders from the right to the left of an army in extended order, and thus are able to set thousands moving as one at the same instant over miles of distance.

In fact, the electrical engineer is dealing with a force whose uses have become, and promise to become, even more in the future than in the past, so varied that, more than any profession, a man has to be a hustler all the time, or he will become a way-back even while he is positive he is well to the front. The up-to-date man of to-day is rear-guard to-morrow if he is not always on the alert, so rapid are the movements, so numerous the applications of the electrical forces.

Electrolysis of Underground Water Mains

By A. A. KNUDSON

ELECTROLYSIS of metals underground often results in injury at points ordinarily inaccessible, and consequently goes on unnoticed until a great deal of damage has been done. The joints of underground mains particularly suffer in this respect.

The fact has long since been established that a portion of the return trolley current passes by way of the mains according to the law governing divided circuits. This being the case, there can be hardly any part of the piping system of a city without some current flowing through it at different times of the day or night. In some cases the flow, with varying strength, is practically continuous, while in other cases a small current only may be passing.

The variation of the strength of the current passing through mains depends entirely upon the traction service in a city or town. This fact has often been demonstrated by observations taken at 5-minute intervals for 24 hours. It has been shown that during the small hours of the night,—from 2 to 5 o'clock,—very little or no trolley current is passing through the mains, even though the power house continues in operation all night. On the other hand, during the day, and particularly at rush hours, the increased strength of flow upon the mains is most marked. This variable flow is coincident, therefore, with that upon the railway lines.

In a paper read by the writer before the New England Water Works Association at Boston, Mass., in December, 1900, the following statement was made with reference to the effect of joint resistance on water mains:—

"This part of the subject we think is fully as important as any other, for the reason that it affects a larger area in the piping system of a city; and although of slower action than the more noticeable effects found in the positive districts, it is important as showing that the mains are being aged and damaged while being put to a use en-

tirely foreign to that for which they were intended. The shunting of the current around the joints, either through the moist earth on the outside or through the water on the inside, owing to the resistance of the joint, is the cause of the pitting or softening of the metal on the high potential side."

As the remainder of the paper is published with illustrations in the Journal of the association, Vol. XV, pages 249-250, further reference is not deemed necessary, as the object of the quotation is to simply show that what was said at that time has been more than borne out by subsequent discoveries.

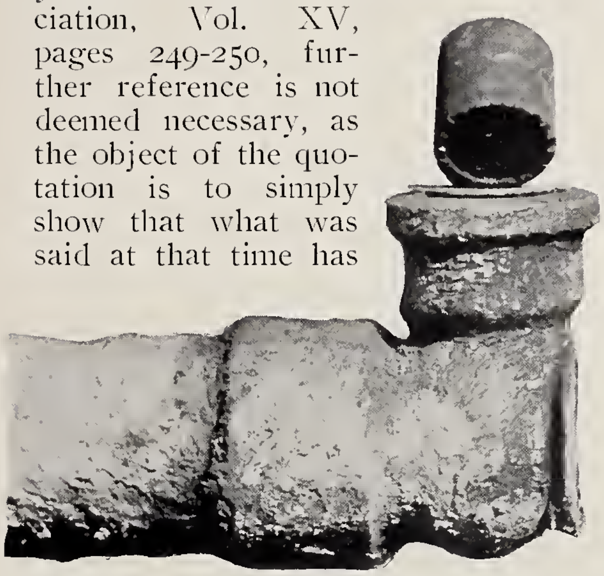


FIG. 1.—THE BASE OF THE HYDRANT. THE SPIGOT END SHOWN IN FIG. 2 IS RESTING ON THE BELL PORTION OF THE JOINT

Among many such cases which have come under the writer's notice, the most recent one will serve as an illustration. Fig. 2 is an illustration of the spigot end of a joint in a 4-inch cast-iron water main, the joint being at the base of a hydrant. A leak having developed, an excavation was necessary, and it was decided at the time to replace the hydrant with one of larger size. When the hydrant and branch pipe were removed and examined, the cause of the leak was found to be electrolysis. As shown between the chalk lines in the illustration, a furrow of pittings extended half-way around the pipe near the edge of the lead packing. The end of this pipe, as can be seen, was also softened for about $\frac{3}{8}$ inch in depth. The current was carefully traced flowing from the main to the branch pipe and out to the soil.

Fig. 1 shows the base of the hydrant with the damaged end resting on the bell portion of the joint from which it was removed. The base of this hydrant rested in wet clay soil, thus making a good "ground," to which a portion of the current flowing through the main was attracted. The iron base from which this current passed out was also found to be considerably affected, electrolytic pittings covering nearly the entire surface.

It will be observed that this joint leak was not in a regular line of pipe, but in a hydrant branch, to which only a portion of the current flowing through the main proper was diverted. It shows that even a small current flowing through mains is quite capable of causing material damage and expense for repairs.

The point which the writer believes important in this feature of electrolysis of underground mains is the unknown damage constantly being done to joints in a wide area of cast-iron mains, as well as in wrought-iron joints at the screw couplings. When leaks at the joints develop, the usual practice is to uncover the main and recaulk the lead packing until the leak is stopped. If the cause of the leak be electrolysis, it is not discovered unless the main is taken apart, because, occurring inside the joint, it cannot be seen, and the leak is attributed to other causes.

The writer believes that there are many such cases in different cities, particularly in those where the mains are connected to the trolley rails or directly to the power house negative. In such a case the tendency for the current to flow in the mains is greater, and the danger of damage to joints is largely increased.

It has often been found in the writer's experience that a flow of from 30 to 50 amperes of railway current was passing through a main, while at other times, when mains were connected to the rail returns, 300 or more amperes have been detected. In the latter case electrolytic pittings may be found on the positive side of nearly every joint when it is carefully examined upon the outside surface.

Evidence of this joint corrosion is sometimes indicated by the frequency of leaks. In one case the engineer of a large water works stated in his annual report that several suspicious leaks had occurred at the joints in their piping system, and he believed it was due to electrolytic action, as it was known that a large amount of railway current was flowing through the mains.

This feature of pipe deterioration, therefore, while a slower process than the more acute causes of mains bursting, is none the less important, because, as has been stated, a large area of the piping system is subject to this action, causing ultimately a shortening of the life of the system.

The prime cause of electrolysis is the "grounded system" used by the railway companies, and while this system is in use it is doubtful if the return currents can be so modified or controlled that underground mains will be free from danger of electrolysis.

While the old adage "Out of sight out of mind" may apply to the electrolytic deterioration of joints, it is important for railway companies, as well as owners of underground property, to know of what is taking place, as the paying of heavy damages for pipe destruction is among the possibilities of the future.

A school for telegraphy and stenography has been established by the Canadian Pacific Railway at Montreal, for the benefit of its employees.

FIG. 2.—THE SPIGOT END OF A JOINT IN A 4-INCH CAST-IRON WATER MAIN. THE PITTINGS BETWEEN THE CHALK LINES EXTENDED HALF-WAY AROUND THE PIPE

Entries for Electric Transmission Lines

By ALTON D. ADAMS

THE entrance of transmission lines into generating plants and sub-stations presents special problems in construction and insulation. One of these problems has to do with the mechanical security of each conductor at the point where it passes through the side or roof of the station, and where the end strain of the line must be met. Conductors are often attached to a station so that the strain of the line is borne by the side wall where they enter and tends to pull it out of line.

This practice has but little to commend it, aside from convenience, for unless the conductors are rather small, or the wall of the station is unusually heavy, the pull of the former is apt to bulge the latter in the course of time. For any heavy line the end strain is ultimately most suitably taken by an anchor securely fixed. As special insulators must be used where a conductor is secured directly to such an anchor, it is usually more convenient to set one or more heavy poles with double cross-arms at the end of a line, and then to make these poles secure by large struts, or by guys attached to anchors. Extra heavy cross-arms on these end poles should be provided with iron pins for the line insulators; two or more of the insulators mounted in this way within a few feet of each other, for each wire, will stand up against the end strain on almost any line.

Insulators that are to take the end strain of a line in this way should allow attachment of the wire at the side, so that the force exerted by each conductor tends to press the insulator against the side of its pin, rather than to pull off the top of the insulator. The end strain of the line having been taken on poles close to the station, the conductors may be attached to insulators on the wall, the latter thus being subjected to very little mechanical strain.

Overhead lines usually enter a station through one of its side walls, but an entry may be made in the roof. It is desirable to have a side entry on the gable end of a building rather than on a side below the eaves where there will be much dripping of water. If an entry must be made below the eaves, a shelter should be provided above the entry, and the roof of this shelter should have a gutter that will carry water away from the wires.

Entrance of each conductor into the station must be effected in such a way that ample insulation of the circuit will be maintained, and in some cases so that rain, snow and wind will be excluded. The line voltage and the climate where the station is located thus have an important bearing on the form of entry that is suitable in any particular case.

The simplest form of entry for a high-voltage line is a clear opening, usually circular in form, through the wall of the station for each wire. Insulators for each wire should be provided both inside and outside of the wall to hold the wire at the center of this opening. Such insulators are usually most conveniently supported by fixtures attached to both sides of the wall, and insulators on the outside should of course be kept in an upright position, unless completely protected from rain and snow.

The diameter of the openings through the wall should be great enough to prevent any visible discharge of current between the wire and wall under the worst conditions of snow, rain, fog or dust. Such an opening must, therefore, increase in diameter with the voltage of the line. The larger these openings for the line wires, the greater is the opportunity for rain, snow, dust and cold air to enter the station through them.

Openings may be so protected as to keep out snow and rain by means of shelves on the outside of the wall on which they are placed, but such shelters cannot keep out the cold air. If the openings for the entrance of wires are located in the wall of a room that contains air-blast transformers, the area of openings for circuits of very high voltage may be no greater than is necessary to allow the escape of heated air from the transformers. By using air-blast transformers in cold climates, the voltage with which wires may enter stations through perfectly free openings may be materially raised.

The milder the climate, other factors being the same, the higher the voltage of circuits which may enter a station through openings that are free for the movement of air. With circuits of only moderate voltage, say, less than 15,000, it is quite practicable to admit wires to a station through perfectly free openings, in the coldest parts of the United States. With voltages of 20,000 to 60,000 it is often necessary, in the colder parts of the country, to close the opening in the wall through which each wire enters, with a disc of insulating material.

In order to keep the current leakage over these discs within proper limits, the diameters of the discs must increase with the voltage of the circuit. This increase of disc diameter obviously lengthens the path of leakage current over the disc surface. Where the openings in a wall for the entrance of high-voltage circuits are closed by insulating discs about the wires, these discs may make actual contact with bare wires, or the length of wire at each entry may have some special insulation.

In the side wall of the sub-station at Manchester, N. H., the entrance of transmission lines from four water-power plants is provided for by circular openings in slate slabs that are built into the brick work. The transmission circuits from three of the water-power plants operate at 10,000 to 12,000 volts, and the circuit from the fourth plant at about 6000 volts. Circular openings in the slate slabs are each 5 inches in diameter, and they are spaced 12 to 15 inches between centers. A single wire enters through each of these openings and is held at the center by insulators both inside and outside of the wall. Each wire is bare where it passes through the slate slab, and the circular openings are not enclosed in any way. The largest wires passing through these 5-inch circular openings in the slate slabs are of solid copper, No. 0, of 0.325-inch diameter each.

Before passing through the openings in the slate slabs the wires of these transmission circuits are tied to regular line insulators supported by cross-arms secured to the outside of the brick wall by iron brackets. The point of attachment of each wire to its insulator is thus about 9 inches below the center of the circular hole by which it enters the sub-station.

This Manchester sub-station is equipped with air-blast transformers from which the hot air is discharged into the same room that the transmission

lines enter. Along one side of the sub-station there are twenty-seven of these 5-inch circular openings in the slate slabs for entrance of the high-voltage lines, and on another side of the sub-station there are a greater number of smaller openings for the distribution circuits. Were it not for the air-blast transformers all of these openings would probably admit more air than would be desirable in a climate as cold as that at Manchester.

Another example of openings in the walls of a station for the entrance of transmission circuits, where there is free movement of the air between the inside and outside of the building, is that of the 33,000-volt line between Santa Ana river and Los Angeles, Cal. In this case a sewer pipe of 12-inch diameter is built into the wall of the station for each wire of the line, so that there is a free opening of this size from inside to outside.

Each wire of the 33,000-volt circuits enters the station through the center of one of these 12-inch pipes, and is thus surrounded by 6 inches of air on every side. As the temperature near Los Angeles seldom or never goes down to zero, these large openings do not admit enough air to be objectionable. Besides this mild climate, air-blast transformers add to the favorable features in the stations having the 12-inch openings.

In another case, however, where the openings for the entrance of wires of very high voltage allow free movement of air between the inside and outside of the station, the climate is cold and the winter temperatures go down to 30 degrees or more below zero. This condition exists on the 25,000-volt line between Apple River Falls and St. Paul, where six No. 2 wires enter the generating station through plain circular openings in the brick side wall of a small extension where the lightning arresters are located. Air-blast transformers are located in the end of the station next to this lightning-arrester house, but it is not certain that the hot air from them escapes through the openings for the wires.

In another case where the climate is about as cold as that just named, a gallery is built along one side of the exterior of the station at some distance above the ground, and two openings are provided for each wire of the high-tension line. One of these two openings is in the horizontal floor of the gallery and allows the entrance of the wire from the outside, and the other opening is in the side wall of the station against which the gallery is built. The two openings for each wire being thus at right angles to each other, and the opening to the outside air being protected from the wind by its horizontal position, no more than a permissible amount of cold air, it is said, finds its way into the station.

In some cases with lines of moderate voltage, say, 10,000 to 15,000, and in probably the majority of cases with lines of 25,000 volts or more, the entry for the high-tension wires is entirely closed. An example of this practice may be seen at the various sub-stations of the New Hampshire Traction Company, which are located along their 12,000-volt line between Portsmouth and Pelham, in that State.

For the entry for each wire on these lines a 16-inch square opening is found in the brick wall of the sub-station. On the outside of this wall a box is built about a group of three or more of these openings located side by side. The top or roof of this box is formed by a slab of bluestone 3 inches thick, which is set into the wall and extends 26 inches from the face of the wall, with a slight slope from the horizontal.

The ends, the bottom and the outer side of this box are formed by slabs of slate 1 inch thick, so that the enclosed space has an area in vertical cross-section at right angles to this building 15½ inches high and 22 inches wide.

In the bottom of this box there is a circular opening for each wire, and into this opening fits a heavy glass or porcelain bushing through which the wire passes. After reaching the inside of the box the wire turns at right angles and passes through the 16-inch square opening into the sub-station. Beneath the box a special insulator is secured by an iron bracket to the outside of the brick wall for each line wire, and this insulator takes the strain of the wire before it is carried up through the bushing in the bottom of the box. This form of entry is permissible where the desire is to exclude cold air from the station, and where the voltage is not high enough to cause serious leakage over the surface of the slate forming the bottom of the box. In all of the cases above mentioned the wires used to enter the stations were the regular line conductors and were bare.

Another type of entry in sub-stations is that employed on the extensive transmission system between Spier Falls, Schenectady and Albany, N. Y. The maximum voltage on this system is 30,000, and the lines usually enter each sub-station through the brick wall at one of its gable ends. Outside of and about the entry of each circuit or group of circuits a wooden shelter is built on the brick wall of the sub-station. Each shelter has a slanting roof that starts from the brick wall at some distance above the openings for the entrance of the line, and terminates in a gutter. The front of each shelter is carried down 3 feet below the center of the openings in the brick wall, and the ends go still lower. The front of each shelter is 4 feet in height, is 4 feet from the face of the brick wall and has a circular opening of 10-inch diameter for each wire of the transmission line.

In line with each circular opening in the wooden shield there is an opening of 15-inch diameter in the brick wall of the sub-station, and into this opening in the brick work fits a ring of wood 15-inch outside and 11-inch inside diameter. To this wooden ring a 15-inch disc of hard fibre ⅛ inch thick is secured, and a porcelain tube 24 inches long and of 2-inch inside diameter passes through a hole in the center of this disc. Within the wooden shield and in line with each circular opening in it and with the corresponding porcelain tube through the fibre disc, a line insulator is secured. Within the sub-station and in line with each tube there is also an insulator, and the two insulators near opposite ends of each tube hold the line wire that passes through it in position.

Each wire of the transmission lines, of which the largest is No. 000 solid of 0.410-inch diameter, terminates at one of the insulators within the wooden shield, and is there connected to a special insulated wire that passes through one of the porcelain tubes into the sub-station. A copper trolley sleeve 12 inches long is used to make the soldered connection between the bare line wire and the insulated conductor that passes through the porcelain tube. Each of these entry cables, whatever its size, is insulated first with a layer of rubber 9-32 inch thick, then with varnished cambric wound on to a thickness of 9-32 inch, and lastly with two layers of weather-proof braid outside of the cambric. This form of closed entry for the transmission lines obviously excludes snow, rain, cold air and dust from the station. Whether the porcelain tubes, fabric discs and wooden rings, together with the insulation on the entry cables will permanently prevent serious leakage of current and the consequent burning and charring, is another question.

Another instance where the entry for a high-tension line is closed with the aid of combustible material is that of the 25,000-volt transmission between the water-power plant at Chambly, on the Richelieu river, and the sub-station in Montreal. The four three-phase circuits of this line are made up of No. 00 wires of 0.365-inch diameter each, which enters the power station and the terminal house in Montreal bare, as they are outside.

At each end of the line the wires

are secured to insulators on a horizontal arm with their centers 22 inches outside of an end wall of the station or terminal building. The insulators are mounted with their centers 30 inches apart, and a few inches above the tops of these insulators a corresponding row of wooden bushings pass through the wall with an outward slant.

At the Chambly end of the line each of these bushings is of oak, boiled in stearin, 4 inches in diameter and 12 inches long. At the Montreal end the wall bushings are of boxwood, and each is 4 inches square and 12 inches long. Each of the wooden bushings carries a glass tube, and is itself held in position by the concrete of the wall in which it is located. Entrance to the station by each of the bare No. 00 wires is gained through one of these glass tubes, and cold air and strain effects are excluded.

Quite a different type of closed entry for the wires of a transmission line is in use on that between Shawinigan Falls and Montreal, which operates at 50,000 volts. For the entry for each of the three aluminum cables that make up this line, each cable being composed of seven No. 6 B. & S. gauge wires a tile pipe of 24-inch diameter was set into the station wall. The end of each tile pipe is closed by a glass plate, with a small hole at its center, through which the cable passes.

As the cable is thus held 12 inches from the terra cotta pipe all the way around, any leakage of current must pass over this length of glass surface at each cable.

A heavy coating of frost sometimes collects on these plates, and this increases the amount of current leakage over them. Surface leakage in a case of this sort, of course, varies with the size of the glass plate, and if a tile pipe is used the limit of size is soon reached.

There seems to be no good reason, however, why a glass plate of any desired dimensions should not be set directly into the brick wall of a station for each line wire, and the tile pipes entirely omitted. This plan is followed on the system of the Utah Light & Power Company, which extends to Salt Lake City, Ogden, Provo and a number of other points in that State.

On the 40,000-volt line of that system an entry for each wire is provided by setting two plates of glass into the brick wall, one plate being flush with the inner surface and the other with the outer surface of the wall.

In the center of each plate there is a hole of about $2\frac{1}{2}$-inch diameter, into which a glass or porcelain tube fits. The line wire enters the station through this tube, and it does not appear that any shelter for the glass plates is located outside of the building. An entry of this type for the 40,000-volt line with glass plates in a brick wall at a gable end of the Murphy mill is said to have given satisfactory results during four years, though that wall faces the southwest, from which direction most of the storms come. At this entry each glass plate is not more than 18 inches in diameter, and the wires are about 4 feet apart. On a 16,000-volt line of the same company, a glass plate 12 inches square with a $\frac{3}{4}$-inch hole at its center, and the bare wire passing through without a tube, has given results that were entirely satisfactory.

Two quite different types of entry to stations are used on the 50,000-volt line between Canon Ferry and Butte, Mont. One type, employed at the side wall of a corrugated iron building, consists of a thick bushing of paraffined wood carrying a glass tube 2 inches in diameter, 4 feet long, with a side wall of $\frac{5}{8}$ to $\frac{3}{4}$ inch, through which the line conductor passes.

On the roof of the power station at Canon Ferry a vertical entry is made with the 50,000-volt circuit. For this purpose each line wire is brought to a dead end on three insulators carried by a timber fixture on the roof. A vertical tap drops from each line wire and passes through the roof and into the station. This roof is of wood, covered with tin outside and lined with asbestos inside. Each tap is an insulated wire, and elaborate methods are adopted in the way of further insulation, and to prevent water from following the wire down through the roof.

Over the point of entrance sits a large block of paraffined wood with a central hole, and down through this hole passes a long cylinder of paper that extends some distance above the block. Into the top end of this cylinder fits a wood bushing, and a length of the top wire that has been served with a thick layer of rubber is tightly enclosed by this bushing. The rubber-covered portion of the top wire also extends above the bushing, and has taped to it a paper cone that comes down over the top of the paper cylinder to keep out the water. On the outside of this paper cylinder, at a lower point, a still larger paper cone is attached to prevent water from following the cylinder down through the wooden block. At the lower end of the paper cylinder, within the station, there is another bushing of wood, and between this and the wooden bushing at the top of the cylinder and inside of the paper cylinder there is a long glass tube. Down through this tube and into the station the insulated tap wire passes.

From the experience thus far gained with high-voltage lines, it seems that their entrance into stations should always be at a side wall, unless there is some imperative reason for coming down through the roof. If climatic conditions permit, no form of entry can be more reliable than a plain, ample opening through the wall with a large air-space about each wire. If the opening must be closed, it had better be done with one or more large plates of thick glass set directly into the brickwork of the wall. Some additional insulation is obtained by placing a long glass or porcelain tube over each wire where it passes through the central hole in the glass plates. Each conductor should be bare at the entry, as it is on the line.

In conclusion, the writer wishes to acknowledge his indebtedness to the Transactions of the American Institute of Electrical Engineers for some of the above examples of existing practice in entries for transmission lines.

Street Car Fares in Australia

THE Commissioner of Electric Railways in Australia, Mr. Kircaldie, in a recent conversation while visiting in Canada, had this to say on the system of charging fares on street railways in Australia: "We are the only people that have the tramways under government control. We have not a uniform rate, as you have it in Canada, but the fares are divided in sections, each of which is about 2 miles in length. For each section we charge a fare of two cents, and by this low rate we induce the public to board cars to travel very short distances, often not more than 200 yards. Your Canadian street railways lose considerable business by charging the uniform rate, no matter what the distance is. An evidence of the success of this section-rate plan is the fact that last year our tramways carried 140,000,000 passengers."

Under the encouragement of the Government citizens of Mexico have organized the Mexican Permanent Exposition Company, which is now erecting in the City of Mexico an extensive exposition building, that will be ready for occupancy in October. The company has appointed E. H. Talbot, of New York City, commissioner for the United States, with full power to assign space and arrange details relating to exhibits. Until November 30 Mr. Talbot will be located in the Mexican section, Manufacturers' Building, St. Louis Exposition.

Construction and Insulation of High-Tension Transmission Lines

By M. H. GERRY, Jr., General Manager of the Missouri River Power Co., Helena, Mont.

A Paper Read at the International Electrical Congress at St. Louis, September 12-17

THERE are in America at the present time about ten systems operating regularly at tensions of not less than 40,000 volts and transmitting energy from 60 to 150 miles. Two of these transmissions employ pressures of between 50,000 and 60,000 volts. All of these systems have been constructed within the past decade and, while they represent commercial enterprises of considerable magnitude, their chief interest lies in the possibilities which they suggest for future developments. The following paper briefly discusses the problems connected with the construction and insulation of transmission lines, without touching upon the generation of the high-tension current or its manipulation within the generating or receiving stations. The examples of methods of construction and details of design described are drawn entirely from American practice. The term "high tension" where used refers to electrical pressures such as mentioned above.

GENERAL DESIGN.

In the construction of high-tension transmission lines wooden poles have been used for supporting the conductors almost exclusively; but there is a tendency at the present time to substitute metal, and the more permanent material will doubtless be employed in the future wherever the undertakings are of sufficient magnitude to justify the larger investment. Excellent results have been obtained, however, from the lines now in operation, and the current practice may be followed with a certainty of satisfactory performance and reasonable cost of construction.

Many of the transmission systems are located in a mountainous country difficult of access, and the obstacles overcome have been numerous and varied. Whenever the nature of the service is important, a private right of way has usually been secured and two lines of poles erected.

Cedar poles are used in the majority of cases, but redwood, pine and other woods are also employed to some extent. Cedar has an advantage over the other common woods in that it will last longer in moist ground. The pole tops and butts are frequently treated with coal-tar or some preservative compound, but this practice is not universal. Poles for important transmission lines are usually selected with care and are heavier and of better timber than those for other classes of service. They are of lengths varying from 35 to 75 feet, with diameters at the tops of from 8 to 14 inches.

For conductors, both copper and aluminium are employed. Copper is used as a solid wire in the smaller sizes, and as a stranded cable when of considerable dimensions. Aluminium is now always employed as a stranded cable. With either metal the flexibility, elasticity and strength are improved when in the form of a cable. Copper may be obtained either soft or hard-drawn. The hard-drawn material has greater tensile strength than the soft or annealed, and for that reason is often preferred.

Copper conductors should not, however, be subjected to a greater strain in service than the limit of safety of the soft metal, for the reason that the hard-drawn material may be annealed locally, either during erection while making connections or while in service by the heating of a joint, or from a short circuit. Aluminium is much the lighter metal for equal conductivity, and this is of some advantage during construction. On account of the greater coefficient of expansion of aluminium more attention is necessary to temperature conditions at the time of erection, so as to limit the sag and resulting stress developed. Equally good results may be obtained, however, with either metal if properly installed.

The cross-arms in use on most transmission lines are either of fir, or of long-leaf, yellow pine. Selected timber is usually employed, and the cross-arms are of special dimensions for this service. In the future, structural steel will probably be used to a considerable extent for this purpose.

The pins supporting the insulators are made either of wood or of metal. Of the various kinds of wood, locust, oak and eucalyptus are mostly in use. Mountain locust from old trees is perhaps the most satisfactory, but it is difficult to obtain. Oak, if well seasoned, gives good results, and eucalyptus has some excellent qualities. Metal pins are made of steel or cast-iron. Steel pins are the more reliable, as they are not subject to flaws and do not fail from internal strains. For fastening together the poles, cross-arms, braces and pins, through bolts are now usually employed.

Various details of construction from current practice are shown in the examples following:—

The standard pole construction of the Washington Water Power Company, of Spokane, Wash., is shown in Fig. 1. This company has recently completed an important transmission from Spokane to the Coeur d'Alene

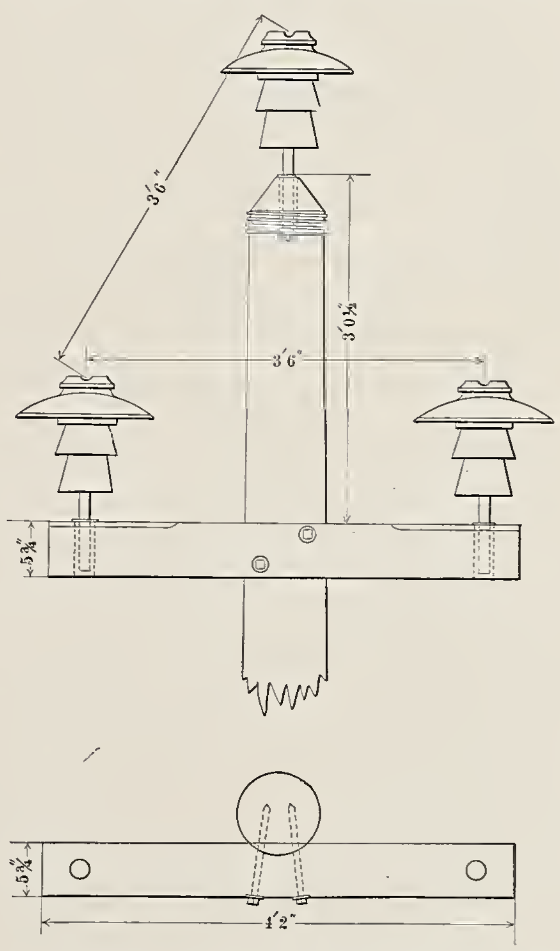


FIG. 1.—POLE-TOP FOR HIGH-TENSION LINE OF THE WASHINGTON WATER POWER COMPANY

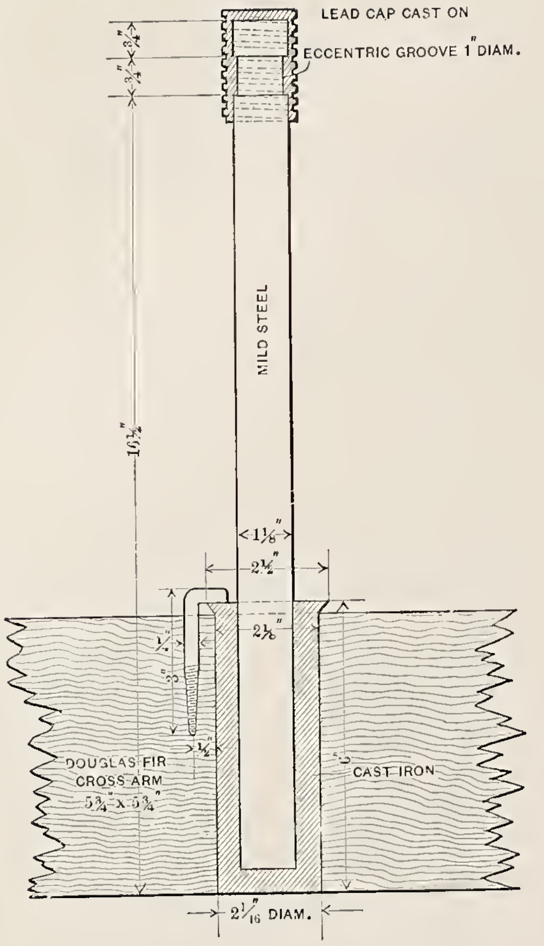


FIG. 2.—COMPOSITE PIN FOR HIGH-TENSION INSULATOR FOR THE WASHINGTON WATER POWER COMPANY.

mine district, 100 miles in length, and designed for an ultimate tension of 60,000 volts, although now operating at 40,000 volts. The conductors are of No. 2, B. & S. gauge, medium hard-drawn, solid, copper wire. The insulators are of porcelain and are brown glazed. The distinctive features of this construction are the short distance of 42 inches between the conductors and the special form of steel pin employed to support the insulators. This pin is illustrated in Fig. 2 and is worthy of notice. It was designed by D. L. Huntington, general manager of the company.

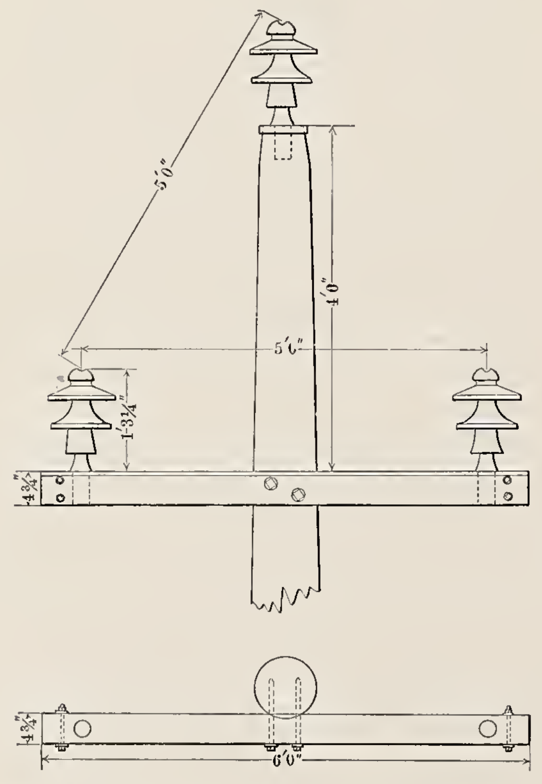


FIG. 3.—POLE-TOP FOR THE SHAWINIGAN TRANSMISSION LINE

Another interesting illustration from current practice is shown in Fig. 3, which is the pole top used by the Shawinigan Water & Power Company, on the St. Maurice River, Canada, for their Montreal transmission. The length of this line is about 84 miles, and it is now operating at 53,000 volts. The conductors are aluminium cable, each made up of seven strands of No. 7 wire. The insulators are of porcelain, made in three parts, and are supported on wooden pins. They were especially designed for this installation by Ralph D. Mershon, the consulting engineer of the company.

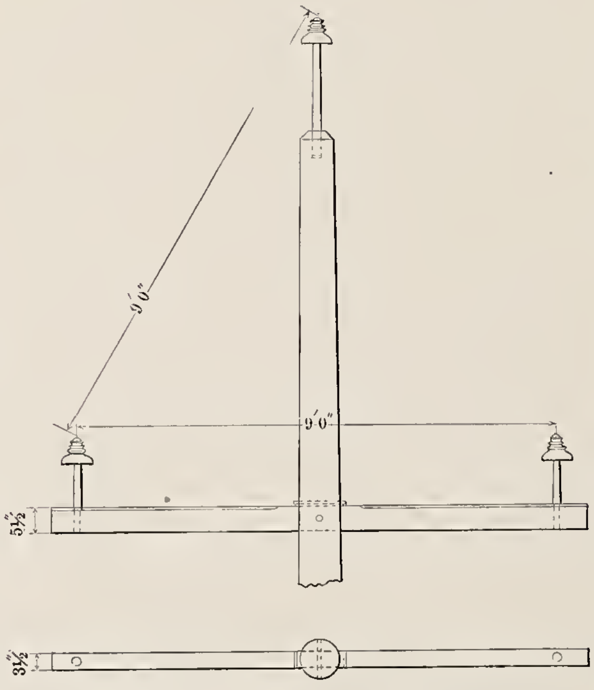


FIG. 4.—POLE-TOP FOR THE MADISON RIVER TRANSMISSION

A novel construction is shown in Fig. 4. This is the arrangement used by the Madison River transmission running into Butte, Mont. It is remarkable for the entire absence of metal, with the exception of the conductors. The cross-arm extends through the pole and is held in place by wooden wedges and a wooden pin. This line is about 70 miles in length and operates at 40,000 volts. It employs glass insulators supported by wooden pins, and the conductors are of aluminium cable. It was built under the direction of P. N. Nunn.

A transmission which employs steel towers for supporting the conductors has just been completed in Mexico by the Guanajuato Power & Electric Company. Fig. 5 shows a standard tower and Fig. 6 the arrangement of cross-arms, pins and insulators. The towers are of a type used for supporting windmills and are of very light construction, the various parts being fastened together by means of special-bolted fittings. All the metal parts are galvanized. The towers are supported by anchors held in place by concrete foundations located at the four corners of the structure. A length of extra heavy 3-inch pipe, supporting the cross-arm and the top pin, extends above the tower. The pins are of cast-iron and the insulators of porcelain. The spans are said to average 500 feet, while the sag of the conductors is about 18 feet. The conductors are of hard-drawn copper cable. This transmission is intended ultimately to operate at 60,000 volts.

As a further illustration of current practice, the high-tension lines of the Missouri River Power Company, of Helena, Mont., built under the direction of the writer, are here briefly described. This transmission has been in service for over three years, operating at 57,000 volts and delivering power at a distance of over 65 miles in a satisfactory manner. The country through which it passes is very rough, as is shown in Fig. 7.

The lines leave the generating station at an elevation of about 3700 feet, and pass over three distinct summits, including the Continental Divide, at which point they reach an elevation of 7300 feet above sea level. There are two parallel lines extending from the generating station on the Missouri River at Canon Ferry, Mont., to the Butte sub-station. These are located mainly on a private right of way 200 feet in width, from which all timber was removed, as shown in Fig. 8. Each of the lines carries three copper cables arranged in a triangular position, 78 inches apart. The cables are composed of seven strands and have

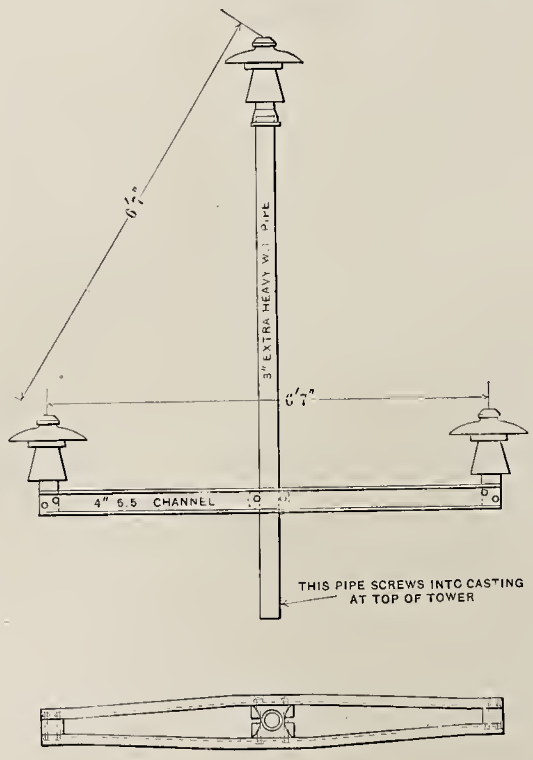


FIG. 6.—POLE-TOP FOR THE GUANAJUATO POWER AND ELECTRIC COMPANY'S LINE

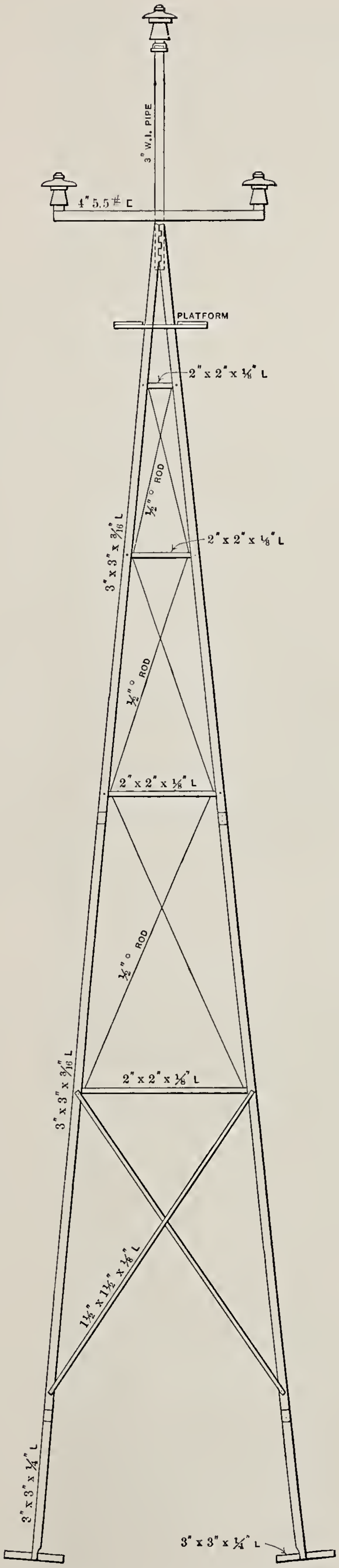


FIG. 5.—FOUR-POST LINE TOWER OF THE GUANAJUATO POWER & ELECTRIC COMPANY, MEXICO

an area of 106,000 circular mils. Fig. 9 is a drawing of the upper part of a standard pole. Fig. 10 is a section of the insulator, sleeve, pin and pole-top.

The poles are of Idaho cedar, the cross-arms of Oregon fir, the braces and pins of white oak, and the insulators and sleeves of glass. The cross-arms, braces and pins are held in place by through bolts. The pins in the top of the poles are of larger size and of greater length than those in the cross-arms, to provide for the greater strains there present. The pins were prepared by being first dried and then treated in paraffine, until all moisture was removed, and were then tested to 60,000 volts. The glass sleeves are not fastened to the insulators and merely rest on a shoulder of the pins, as shown in Fig. 10.

The circuits are transposed five times, making two complete turns between the generating station and the sub-station. The switching arrangements are such that the circuits may be operated either singly or in multiple. A telephone circuit is located on one of the lines and gives good results in service. The poles are from 35 to 75 feet in length, and the pole-tops are from 9 to 12 inches in diameter. The poles are set from 6 to 8 feet in the ground, according to height, and the standard spacing is 110 feet, with a maximum spacing of 150 feet when required by the nature of the ground.

The constructions just described were selected as typical examples of what has been accomplished in the building of high-tension transmissions. Several of the lines mentioned have been in regular operation for periods varying from one to three years, and are in no sense experiments, but rather represent successful commercial undertakings. Other interesting and well-known systems might have been described had the limits of this paper permitted a further expansion of the subject.

LINE INSULATION

The design of insulation for high pressure ought to involve a consideration of all the effects of electrical tension on the dielectric in the vicinity of the conductors. In the case of a line insulator, air is always a dielectric in combination with glass, porcelain, wood or other materials. Wherever there is a difference of electrical potential, there exists in the surrounding media a state of strain called an electro-static field. This state of strain is the result of electrical stress applied to the insulating material.

Dielectrics possess a sort of atomic elasticity, and electrical tensions produce a displacement in the molecular structure which, if carried beyond a certain limit, result in disruptive breakdown of the material. Before a difference of potential can exist current must flow into the dielectric, thus producing a state of strain equal to the electrical stress applied. If the mate-

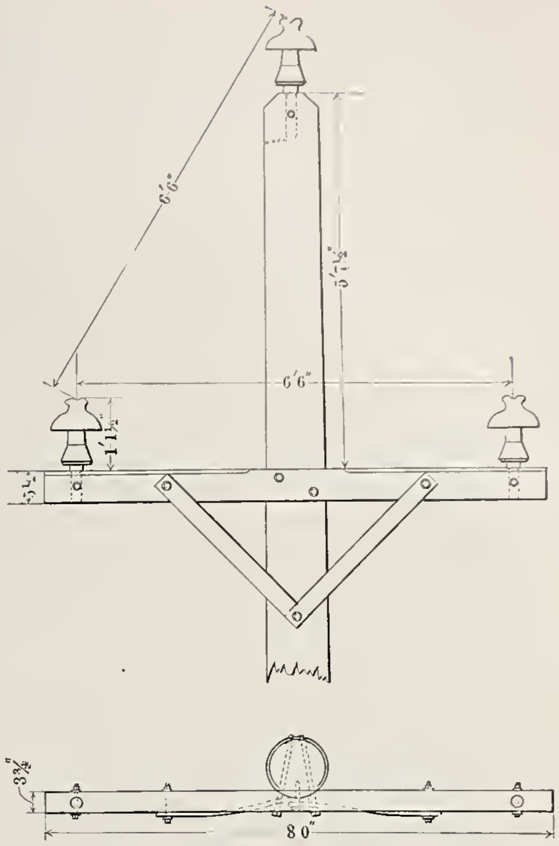


FIG. 9.—POLE-TOP FOR THE MISSOURI RIVER POWER COMPANY'S LINE

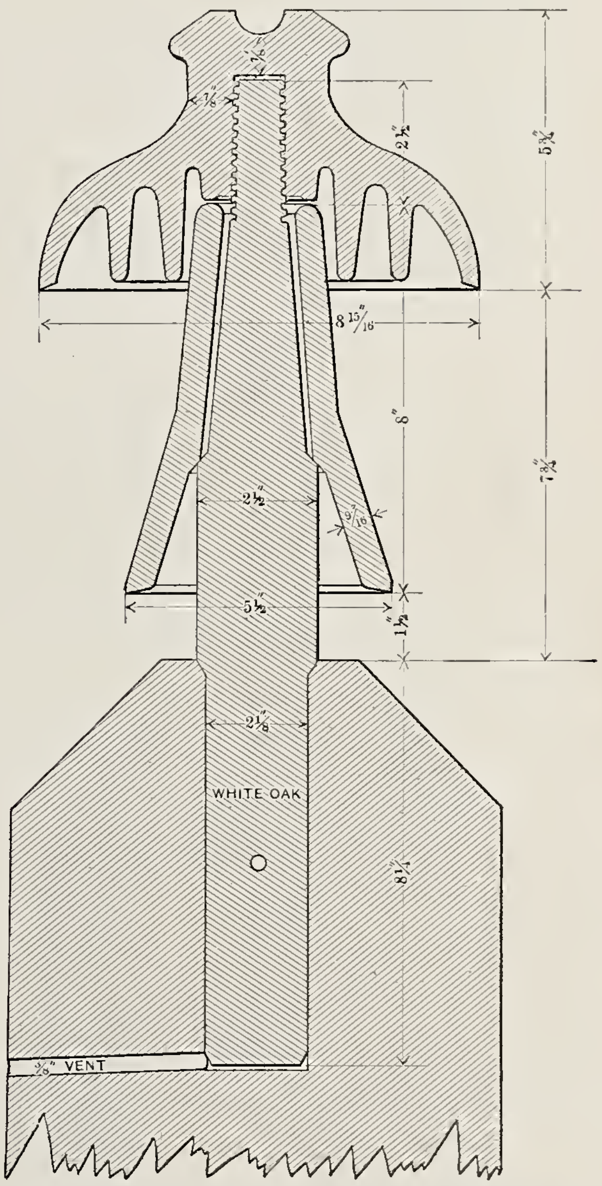


FIG. 10.—SECTION OF THE MISSOURI RIVER POWER COMPANY'S INSULATOR, SLEEVE, PIN AND POLE-TOP

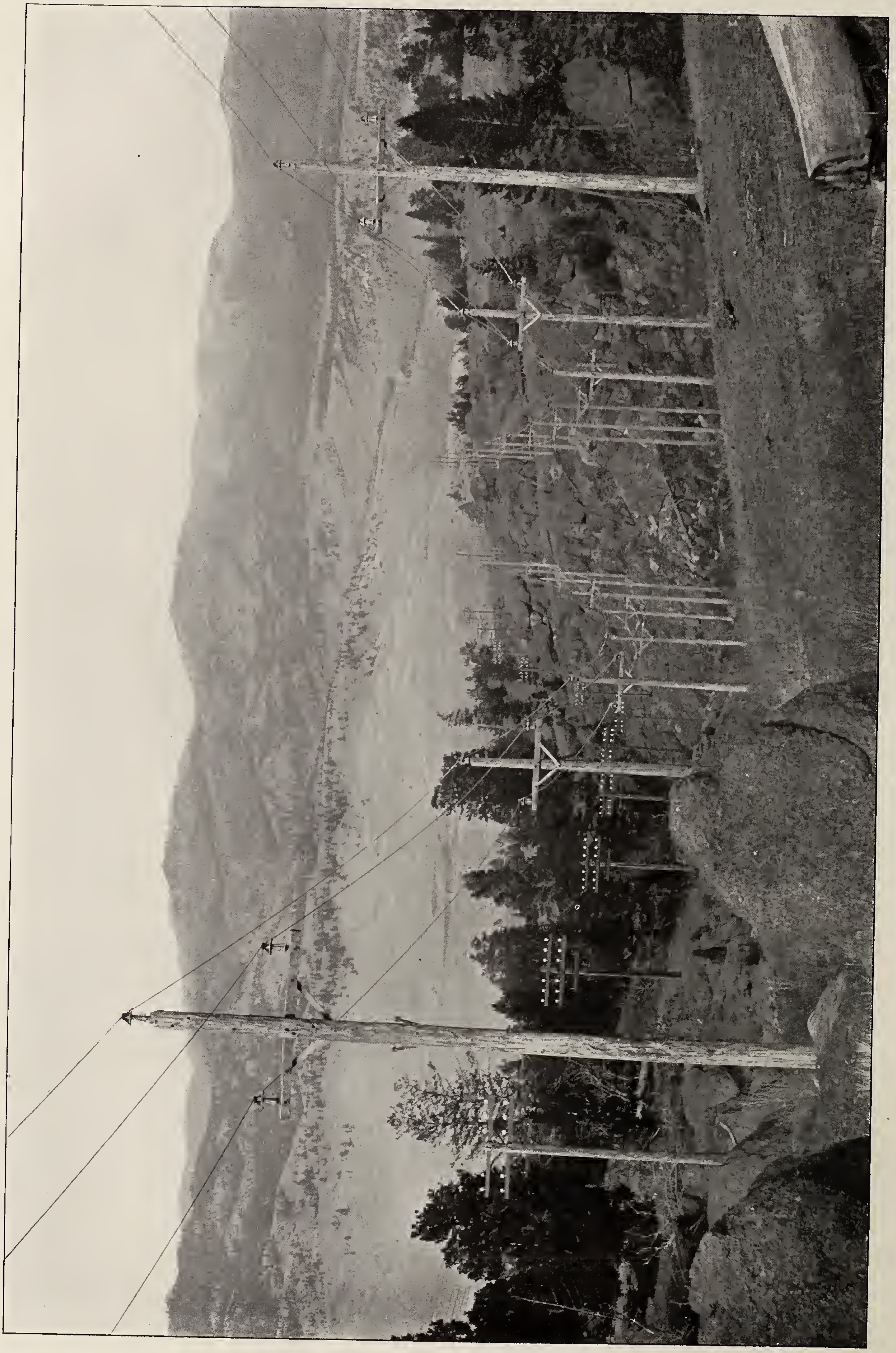


FIG. 7.—THE COUNTRY THROUGH WHICH THE MISSOURI RIVER POWER COMPANY'S LINES PASS

FIG. 8.—ALONG THE LINES OF THE MISSOURI RIVER POWER COMPANY. PRIVATE RIGHT OF WAY, 200 FEET WIDE, FROM WHICH ALL TIMBER WAS REMOVED

rial be not strained beyond its limit of molecular elasticity, current will flow from the material whenever the tension is removed or reduced and a path provided.

All dielectrics possess the quality of receiving strain before rupture, but not to the same degree. Solids and liquids generally possess it in a higher degree than gases. Whenever the limit of strain of a particular material is exceeded it fails structurally, resulting, with a solid, in a mechanical rupture, and, with a gas, in a change of molecular state which reduces its electrical resistance and renders it semi-conducting. It frequently happens, when several dielectric materials are subjected to the same electro-static field, that one or more of the materials will be strained beyond the limit and will fail, although the others may withstand the electrical strain. Air adjacent to powerful dielectrices frequently fails in this manner, thus giving rise to the common brush discharge.

The structural failure of air, from an engineering standpoint, has been studied by a number of investigators, including C. P. Steinmetz and Prof. Harris J. Ryan. It is well known that air at ordinary pressures and temperatures has a much lower dielectric strength than the common, solid, insulating materials. Air in thin films adjacent to solid bodies has greater strength than in bulk, but is still inferior to such substances as glass, porcelain, mica, treated paper, and the like. The dielectric strength of air is affected by the physical condition and varies directly as the pressure and inversely as the absolute temperature. Under uniform conditions all dielectrics rupture at definite, applied tensions. Prof. Ryan has shown that there exists also for each dielectric material a certain strength of electrostatic field which will cause rupture. When several materials in series form the dielectric, the one rupturing at the lowest value of electro-static field will fail first, although individually it may possess superior qualities.

Line insulators are usually made of glass or porcelain, fashioned into a variety of shapes, all approximating certain elementary forms. Consider that alternating electrical tension is applied to a solid insulating disc, as shown in Fig. 11. If the pressure be low, only charging current will flow, but, if the tension be increased sufficiently, the air under and about the electrodes will be ruptured, producing brush discharge. This results in the formation around the electrodes of a zone of ionized air of comparatively low resistance. This enveloping zone of conducting air has the effect of increasing the size of the electrodes and, thus, the area to which the full tension is applied.

If the tension be further increased, the zone of ionized air continues to spread over the surface of the disc, thereby increasing its capacity and the resulting charging current. Streamers will now form on the surface of the plate and afford a path of still lower resistance whereby the current for charging the dielectric and ionizing the air is conducted to the outer portions of the ruptured zone.

When the surfaces of the solid dielectric are parallel, as in this case, the streamers and ruptured air zone, when once started, would apparently continue to spread indefinitely, were it not for the cooling effect of the adjacent material, the appreciable resistance of the path through the ionized air and the time element intro-

duced by the alternating pressure. Under the conditions as shown in Fig. 11, the streamers may unite over the edge of the plate, thus forming a short circuit, the distance traveled being several times as great as the breakdown distance through air for

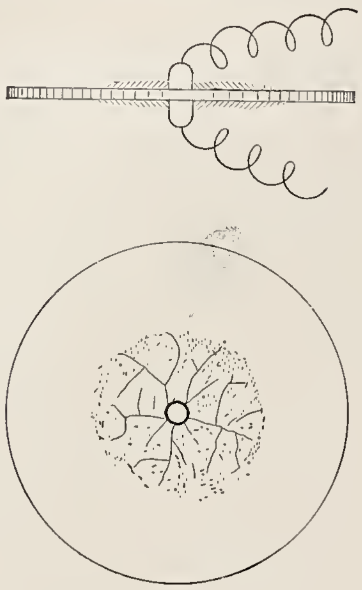


FIG. 11

the same pressure. This result is not due to surface leakage, as frequently assumed, but is a phenomenon of electro-static capacity and local structural failure of the air as a dielectric.

If, instead of the pressure being applied to a small area, as in Fig. 11, the electrode be enlarged to a plate, as shown in Fig. 12, the same results will follow, but the spreading out of the ruptured air zone will take place

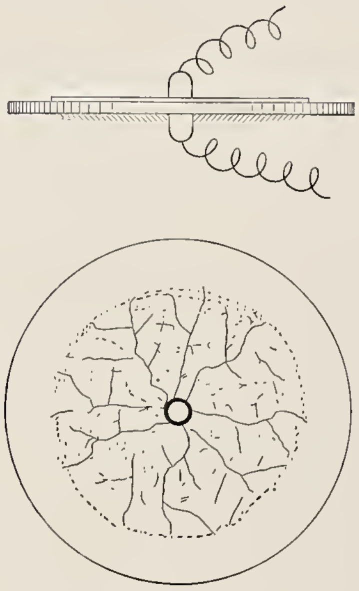


FIG. 12

on one side only and at a considerably lower tension.

If pressure be applied to an insulating tube by means of a conductor inside and outside, as shown in Fig. 13, the air will fail at a certain tension, and the results will be similar to those obtained with the plate in Fig. 12. The streamers will start from the conductor on the outside at *A* and will run along the tube from the center towards the ends, the tendency being to cover the outer surface with an enveloping coating of ruptured air. In this, as in all other cases, the streamers are drawn out in such a direction as to increase the electro-static capacity.

If a still greater tension be applied, the streamers from *A* will finally draw sufficiently near to *B* to cause rupture of the air in bulk between *B* and the ends of the streamers extending from *A*.

If, under these conditions, the internal conductor be now removed from the tube, as shown in Fig. 14, the air about the point *A* will no longer be ruptured, and the streamers will cease,

FIG. 14

although the distance between *A* and *B* and the conditions for surface leakage remain as in Fig. 13. It will now require a material increase of tension

FIG. 15

to cause a breakdown between the electrodes, and this will occur essentially as if the tube were not present.

After initial rupture of the air, the spreading of the streamers is effected

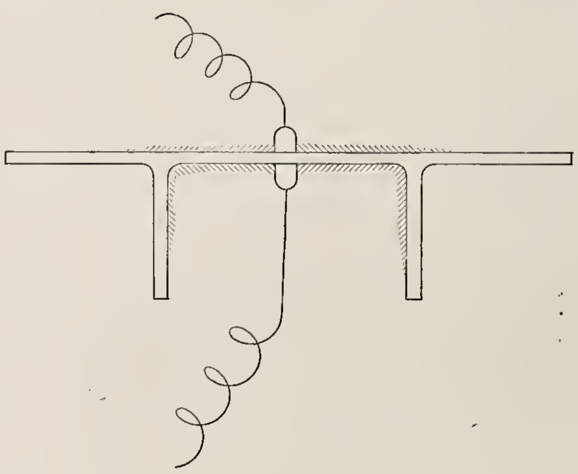


FIG. 17

to a degree by the form of the solid dielectric. Fig. 15 indicates tension as applied to a dish of uniform thickness; Fig. 16 to a deep receptacle; and Fig. 17 to a special form. The results obtained from the arrangement shown in Fig. 15 will not differ materially from those obtained from the arrange-

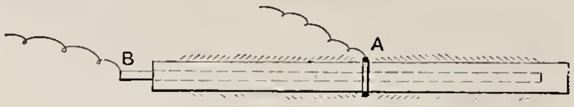


FIG. 13

ment shown in Fig. 11 or, if one surface be made conducting, from those obtained from the arrangement in Fig. 12.

In the case of Fig. 16, however, the air in the interior of the receptacle around the entering conductor becomes ionized at sufficient tension, and the conditions then existing are the same as if the receptacle were filled with a conducting substance. With the arrangement in Fig. 17 the streamers start as in Fig. 11, but upon reaching the downward projection they are forced along its surface and away from the streamers on the upper face of the

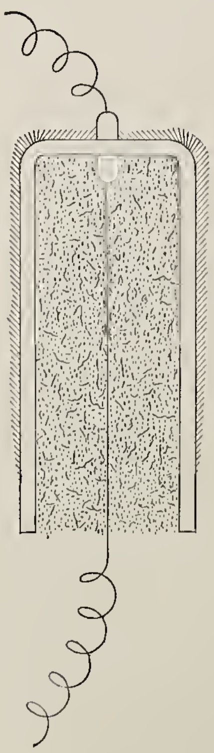
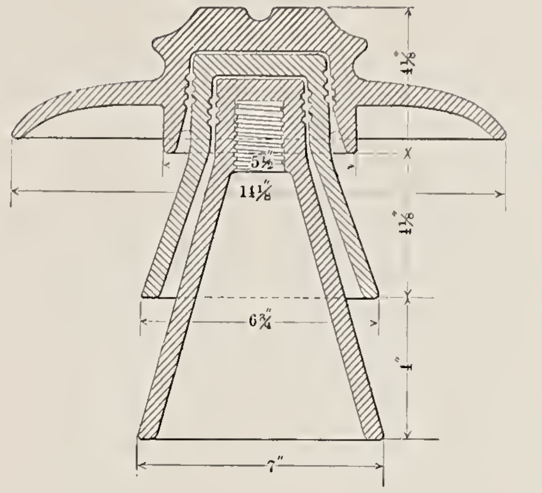


FIG. 16

plate, until a point is reached where the electro-static field is no longer sufficient to rupture the air, when the streamers die out and further spreading of the ruptured air zone ceases.

All line insulators are made from variations of the forms just discussed. Surface insulation has little to do with their performance, and unless the faces



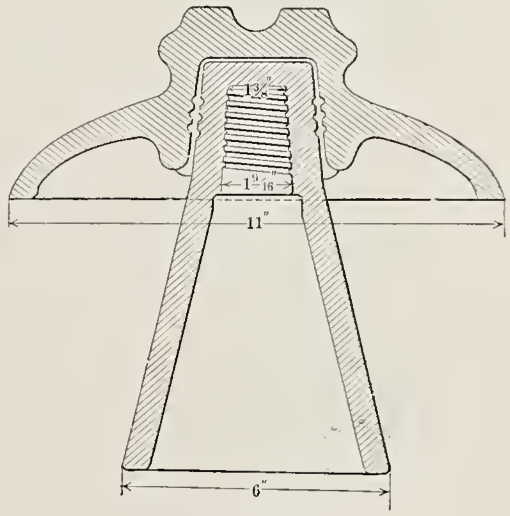
FIGS. 18 AND 19.—BROWN GLAZED PORCELAIN INSULATOR MADE BY THE LOCKE INSULATOR MANUFACTURING COMPANY, OF VICTOR, N. Y., FOR THE WASHINGTON WATER POWER COMPANY, SPOKANE, WASH., AND THE STANDARD ELECTRIC COMPANY, OF CALIFORNIA, FOR CARRYING 60,000-VOLT CURRENTS

be made conducting by a coating of water or other foreign material, the surface leakage may be neglected altogether from an engineering standpoint. A wet surface, however, is practically equivalent to the metallic coating illustrated in Fig. 12. For high tensions, wet surfaces ought to be considered as conductors; but dry surfaces need be treated only in relation to the electro-static phenomena already described.

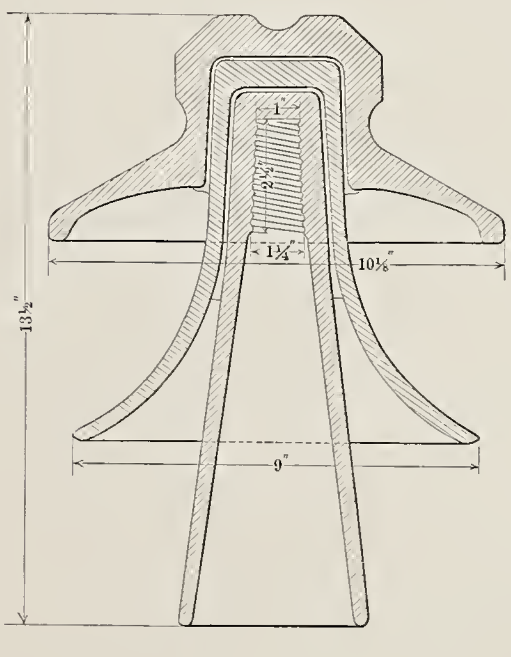
A first consideration in connection with the design of a line insulator is its ability to maintain dry surfaces under all weather conditions. It has been frequently assumed that rain descends at an angle not exceeding 45 degrees from the vertical, but this is not a safe basis for design. When rain is accompanied by wind at high velocity, and especially if the air currents be unsteady and in gusts and subject to deflection on account of the irregular contour of the country, it will then be found that at times the rain travels practically in a horizontal plane. As the rain-drops are often moving at high velocity, there will be also considerable splashing of the water where it meets obstructions, and this must be considered in predetermining the dry surfaces. With insulators of the "umbrella" type, there frequently results a wetting of a portion of the under side of the main petticoat from water splashed from other parts. The shape of the insulator may also result in deflecting the air currents, thus carrying the rain to surfaces that otherwise would remain dry. Insulators of the "Italian" and "double-story" types are frequently effected in this way. Those of the vertical, petticoat type are especially free from this defect, as the spaces between the petticoats are efficient in preventing eddying air currents from carrying moisture to the under side of the insulators.

After determining the extent of the possible wet surfaces, consideration ought to be given to the distribution of potential on the various parts of the insulator. The tension is applied between the point where the conductor is attached and some other point, depending upon the construction employed. During rains, the entire upper surface of the insulator is at the potential of the conductor, and the ground potential is, at the least, directly under the insulator at the cross-arm. This condition holds with wooden construction as well as with metal.

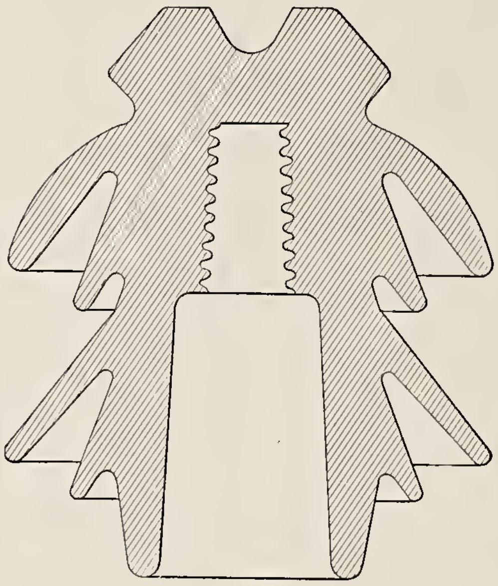
If a conducting pin be employed, the ground pressure will be carried still higher, and the tension will be applied across the comparatively thin material of the upper part of the insulator. The dielectric will then consist of the porcelain or glass at this point and the air adjacent to the conductor and pin. The tension will be that to the ground, and, for a three-phase circuit under normal conditions, will be less than the pressure between conductors; but as there are many operating conditions where full tension may be applied to the insulators, it is better



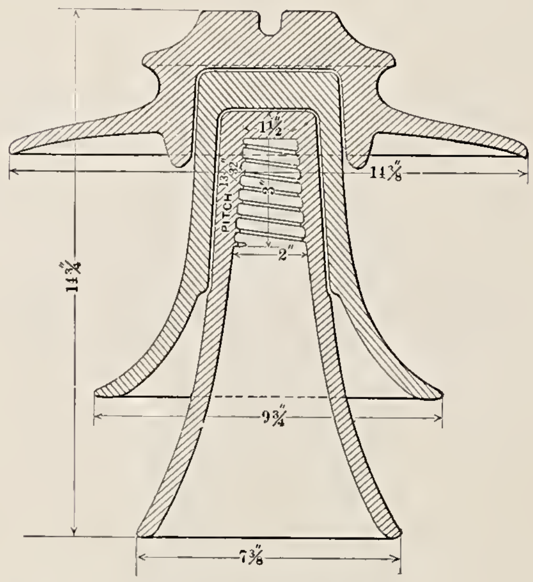
FIGS. 20 AND 21.—A GLASS "UMBRELLA" TYPE INSULATOR



FIGS. 22 AND 23.—WHITE GLAZED PORCELAIN INSULATOR, CARRYING 53,000-VOLT CURRENT FOR THE SHAWINIGAN WATER & POWER COMPANY, CANADA. MADE BY THE R. THOMAS & SONS CO., EAST LIVERPOOL, OHIO



FIGS. 24 AND 25.—SINGLE-PIECE BROWN GLAZED PORCELAIN INSULATOR



FIGS. 26 AND 27.—A BROWN GLAZED PORCELAIN INSULATOR OF LATE DESIGN

practice, for the purpose of design, to assume that this is the case at all times. The form of the pressure curve also has an effect, as it is the maximum tension at the peak of the curve that causes initial failure of the dielectric.

If the tension as applied sets up through the material an electro-static field sufficiently powerful, the air in series with the solid insulating material will be ruptured, and brush discharge and streamers will form, which, unless checked, may extend over the entire insulating surface, causing short circuit. The spreading of the conducting zone of air may be prevented, as previously explained, by the use of very large surfaces, or by employing deflecting projections or petticoats, so arranged as to reduce locally the strength of the electrostatic field to a point at which the air will not be ionized. These methods, however, serve only to stop the spreading of the ruptured air zone and require considerable dimensions for even low factors of safety. All brush discharges are wasteful of energy and are destructive of organic materials. It is brush discharge combined with capacity-charging current that has caused the burning of pins on high-tension lines.

Common wooden pins are practically conductors for high tensions, and the ground pressure is carried up within the insulator. When the pins possess dielectric qualities comparable with the material of the insulators, the tension may be said to be applied between the top and base of the insulator, resulting in a greatly increased thickness of the dielectric material. This usually overcomes brush discharge and materially increases the reliability of the insulator. For the best results, insulators for high tensions ought to be so designed that under no operating conditions would the electro-static field of force ever be sufficient to rupture the air adjacent to the insulating surfaces. This can be accomplished by properly proportioning the thickness of the material exposed to the electric stress.

The general dimensions of the insulator ought, of course, to be such that the direct air path from the conductor to the cross-arm will be sufficient to avoid failure through the rupture of the air in bulk. This is a matter of simple determination, involving only the length of the air path and the dielectric strength of the air in bulk at the extremes of pressure and temperature, as found in service. When insulators are made of several parts cemented together, the dielectric material is no longer homogeneous, and the distribution of the electrostatic strain may be materially altered.

The cements commonly used, such as sulphur, litharge and glycerine, Portland cement, and the like, possess entirely different and inferior electrostatic qualities to the glass or porcelain of which the insulators are made. The cement between the sections is in series with the dielectric material of the insulator, and is exposed to the same electro-static field of force. The strata of cement in some cases redistribute the electro-static charge. Under other conditions, the pressure is conducted directly to the cement through the ruptured air. In this case the semi-conducting cement becomes charged with practically the full terminal pressure, and excessive tension may thus be applied to a section of the insulator not designed to withstand it. This frequently results in sectional breakdowns, and the insulator fails in detail.

The irregular distribution of surface

FIG. 28.—ONE OF THE INSULATORS OF THE MISSOURI RIVER POWER COMPANY, MADE BY THE HEMINGRAY GLASS COMPANY, COVINGTON, KY. A SECTIONAL VIEW OF THIS IS GIVEN IN FIG. 10

potential also affects the outside air path and, in some types of insulators, reduces the tension required to rupture the air between the points of applied tension. When insulators are made up of several parts, the cement employed ought to possess dielectric qualities comparable with those of the component parts, and every effort ought to be made to render the dielectric material homogeneous, so that there may be a uniform fall of potential between the points at which the tension is applied.

The resistance to disruptive breakdown or puncture of the solid dielectric is also of importance. Good porcelain or glass, however, has such great strength in resisting puncture that if the insulator be designed so as to entirely avoid rupture of the air near the points of applied tension, it will be impossible to puncture the insulator under operating conditions. One-piece insulators of glass or porcelain seldom fail from puncture, even if thin at the top, but two or three-part insulators sometimes fail by the puncturing of one or more of the sections, probably owing to unequal distribution of potential, as previously discussed.

Of the various substances available, glass and porcelain have been used almost exclusively for high-tension insulators. Glass has excellent dielectric qualities and can readily be obtained in desirable shapes at reasonable cost. Its greatest defect is its mechanical weakness, which is due almost entirely to internal strains developed during manufacture. Consistent design of the surfaces to obviate as far as possible shrinkage strains and careful annealing have improved the conditions of many glass insulators so as to render them reliable for service, but they still do not possess the mechanical strength of the best porcelain. Glass, however, is a more reliable dielectric material and, from an electrical standpoint, gives better and more uniform results. The best porcelain has great mechanical strength and good dielectric qualities. It is, however, difficult to manufacture in considerable thickness and is very apt to develop flaws and surface cracks. Common grades of porcelain are unreliable and ought not to be used for high-tension work.

While the insulator has been considered chiefly as an electrical device, it is still essential that it be treated as a mechanical support for the conductors, which function it chiefly serves. Practically all the mechanical strains on the insulators and pins are transmitted from the conductor. When the line is level and without angles and when the spans are equal, the strains are due only to the wind and weight of the conductor. When angles in the line occur, a transverse strain is developed. If the line be not level or the spans not equal, strains, having vertical and horizontal components, are produced. All the necessary calculations for the forces acting and the resulting strains can be readily made by the ordinary rules of mechanics and do not here require consideration.

The following examples of high-tension insulators were selected as representing American practice:—

Fig. 18 shows a brown-glazed, porcelain insulator, of the "umbrella" type. It is made in three parts cemented together, as indicated in the section drawing, Fig. 19. It weighs about 20 pounds. This insulator is in use by the Washington Water Power Company, already referred to in this paper.

Fig. 20 is a general view and Fig. 21 a section of a glass insulator, also of the "umbrella" type. It is made of two parts cemented together and weighs 13 pounds.

Fig. 22 shows the insulator in use by the Shawinigan Water & Power Company, now operating at 53,000 volts. It is of white-glazed porcelain, in three parts. Its dimensions are given in the section, Fig. 23. This insulator also weighs 13 pounds.

Fig. 24 is a single-piece insulator of the "Italian" type. It is made of fine porcelain, brown-glazed, and weighs $7\frac{3}{4}$ pounds. Fig. 25 shows its section.

Figs. 26 and 27 show a porcelain insulator of late design. It is brown-glazed, is made in three parts and weighs 26 pounds.

Fig. 28 is the standard insulator of the Missouri River Power Company and is in regular service at 57,000 volts. It is of glass, is made in two parts, and has already been shown in section in Fig. 10. Its weight is $12\frac{1}{2}$ pounds.

The developments in the construction and insulation of high-tension lines have now reached a point where no doubt exists regarding the practicability of transmitting energy at tensions approximating 60,000 volts. From this time on it will be rather a question of expediency and engineering detail to determine the best methods of obtaining the desired commercial results. For pressures above 60,000 volts the field as yet is unexplored, but those who have followed this subject carefully agree that much higher tensions will ultimately be employed. The practices discussed in this paper cover what has already been accomplished, but seem also to point the direction for future development in this branch of engineering.

Difficulties of Telephone Line Construction in Abyssinia

According to "The Morning Post," of London, civilization, represented by the telephone, is proceeding rapidly in Abyssinia. Nearly 800 miles of telephone wire have already been put up there, and 1000 miles more are under construction.

The contractor's task, however, is by no means an easy one. Tremendous rainfalls were the first source of damage, washing out many miles of pole line; and scarcely had this damage been made good when the poles again began to fall. This time the cause was white ants. The destruction was stopped by erecting iron poles, but these were torn up by the natives and converted into tools. To put a stop to this, messengers were sent throughout the country proclaiming that extreme punishment awaited those who touched the telephone lines.

The chief trouble at present is given by elephants, who use the poles as scratching posts, knocking them down in this exercise, and by monkeys who swing on the wires. The rapid growth of the jungle also gives some trouble, and makes it necessary to keep gangs of men continually cutting away the new growth.

Artificial Gutta Percha Insulation

The German Telegraph Department has had in use for nearly two years cables insulated with artificial gutta percha. The material is a mixture of rubber and a palm wax of the same melting point as the rubber. Electrically the product is considered equal to the natural gutta percha, and it softens only above 140 degrees, F.

The material is manufactured by Felten & Guilleaume, of Muelheim. The experimental cable is 6 miles in length, and connects the Isle of Foehr with Schleswig. The artificial gutta percha is 35 per cent. cheaper than the real article.

On the occasion of some hill-climbing trials of automobiles near Harrogate, England, there was brought into use for the first time an electrical timing gear. The contrivance was applied with successful results. The breaking of the thread at the starting point liberated a lever which, through electrical communication, set going a stop watch at the other end of the course, and, in like manner, when the rider snapped the thread on passing the finishing post, the watch was immediately stopped, and the time was thus taken to a fifth of a second.

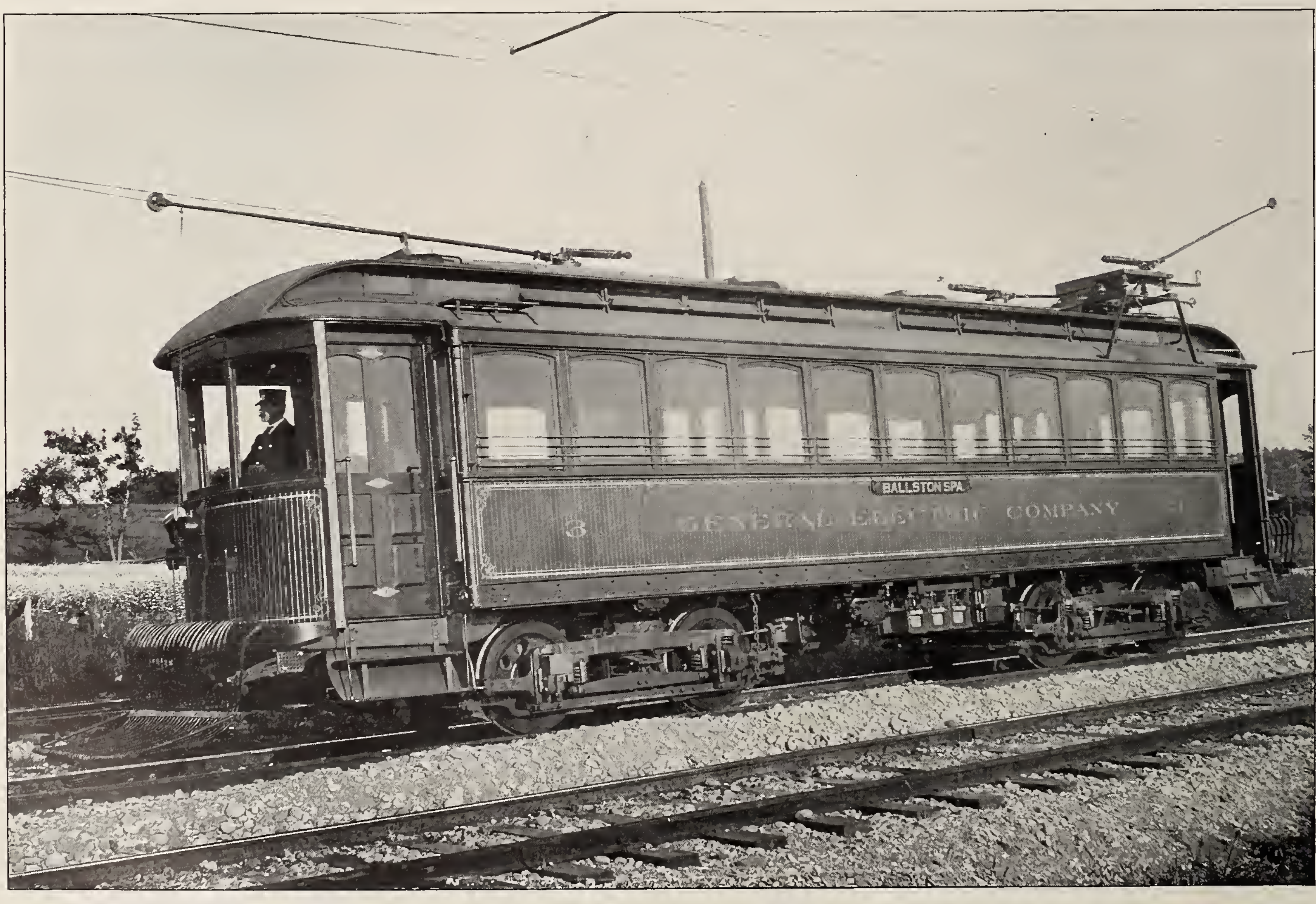
The First Commercial Alternating-Current Railway in America

THE Ballston division of the Schenectady Railway Company, from Schenectady to Ballston, N. Y., about $15\frac{1}{2}$ miles long, affords the first instance in this country of an alternating-current railway in regular service carrying passengers.

The first public test on the Ballston division was made last month with entirely successful results, and through the courtesy of Mr. W. S. Andrews, of the General Electric Company, at Schenectady, and Mr. E. H. Mullen, the company's New York representative, we have been enabled to present the following particulars of the installation and illustrations of the car used, portions of the line, the motors and accessories.

The motors used in the equipment are of the single-phase "compensated" type, developed by the General Electric Company, of Schenectady, and so named on account of the character of the field winding, which fully neutralizes or compensates for the armature reaction. Both the compensated motors and control are adapted for operation on the 2000-volt alternating-current line between cities and the standard 600-volt direct-current line in Schenectady. This ability of the compensated motor equipments to run over tracks equipped with either alternating current or direct current makes their field of application very broad, as the cars can secure all the benefit of running over existing city tracks without in any way sacrificing their running qualities upon suburban sections equipped with alternating current.

The alternating-current motor with its inherent advantages of high voltage distribution is eminently adapted to replace the steam locomotive on either high-speed passenger or heavy freight-haulage work; and as the compensated type of motor is perfectly adapted to operate on both alternating-current and direct-current lines, the alternating-current motor must be considered a large factor in future suburban railway systems. The compensated motor is essentially a variable-speed motor, differing in this respect from the multiphase induction motor, whose constant-speed characteristics proved so serious a handicap to its successful adoption in railway work. The speed-torque characteristic of the compensated motor is very similar to that of the direct-current series motor, while its commutating qualities and method of

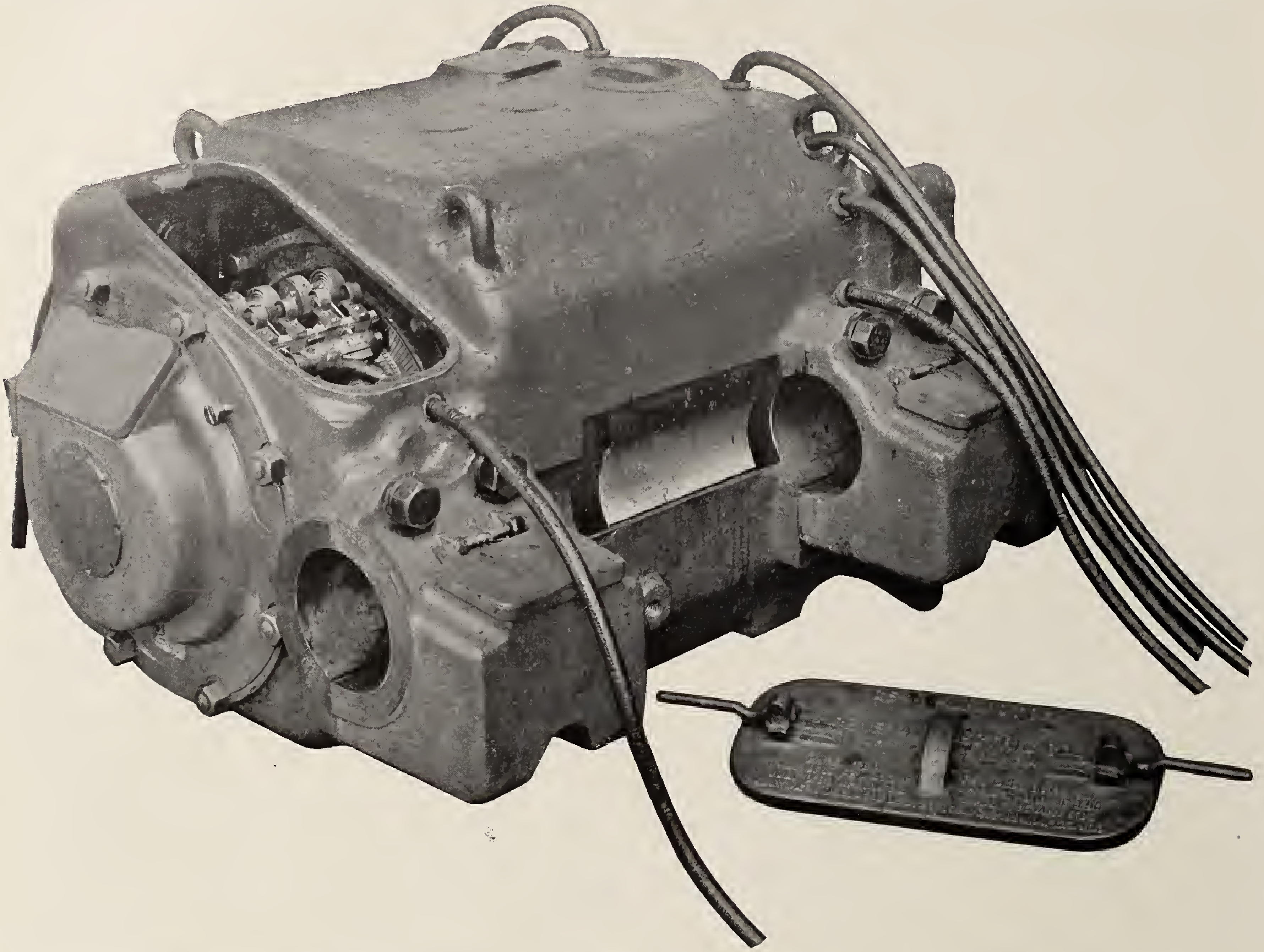


A CAR ON THE BALLSTON DIVISION OF THE SCHENECTADY RAILWAY COMPANY, BUILT BY THE J. G. BRILL COMPANY, PHILADELPHIA, AND EQUIPPED WITH COMPENSATED SINGLE-PHASE MOTORS BY THE GENERAL ELECTRIC COMPANY, SCHENECTADY, NEW YORK

ALONG THE BALLSTON LINE. BOTH THE DIRECT AND THE ALTERNATING CURRENT LINES, USED IN CONJUNCTION, ARE HERE PLAINLY SHOWN

control prove equally satisfactory. On the Ballston extension of the Schenectady Railway, advantage is taken of the ability of the compensated motor to operate with either alternating-current equipments which would not interfere with the direct-current lines. The center poles are 34 feet long and are spaced 100 feet apart, the alternating-current and di- high-potential high-speed work in both its electrical and mechanical features.

With the alternating-current system using a trolley and track return,



FRONT VIEW OF ONE OF THE COMPENSATED ALTERNATING-CURRENT MOTORS MADE BY THE GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

nating or direct current. The extension is 15.5 miles in length, including 3.9 miles of city running in Schenectady over tracks equipped with direct current. The interurban section is double track on private right of way, 60 inches wide, laid with 75-pound T rails, gravel ballast, with maximum grade of 1.8 per cent. Special attention has been given to the high-speed possibilities of the road and no curve exceeds $4\frac{1}{4}$ degrees.

Center-pole bracket construction is used, there being two brackets supporting the two 600-volt direct-current trolley wires and a cross-arm supporting the two 2200-volt alternating-current trolley wires. The Ballston extension has been operated for several months with direct-current equipments, and their operation being continued in part, necessitated an additional set of trolley wires for the

rect-current trolley wires being No. 000 grooved section, with no feeders for the alternating-current trolley and with a 500,000-C. M. feeder reinforcing direct current. The direct-current line conforms to standard bracket construction and presents no unusual features, while the alternating-current trolley wire is suspended from a $\frac{3}{8}$-inch steel catenary. The alternating-current wire is clipped to the catenary midway between poles and the catenary in turn is hung over porcelain insulators on wooden cross-arms, the whole forming a construction of great flexibility with the further advantage of providing excellent insulation with standard porcelain insulators, and eliminating the span wires adjacent to the trolley wire, thereby preventing the pole catching should the trolley wheel leave the wire. This method of trolley construction is well adapted to

there is an inductive drop in the trolley and rails with an additional loss in the latter case, due to eddy currents and hysteresis. Measurements made upon the Ballston line indicate an apparent trolley resistance of 1.3 times the ohmic resistance, and a rail resistance 6.55 times the ohmic resistance.

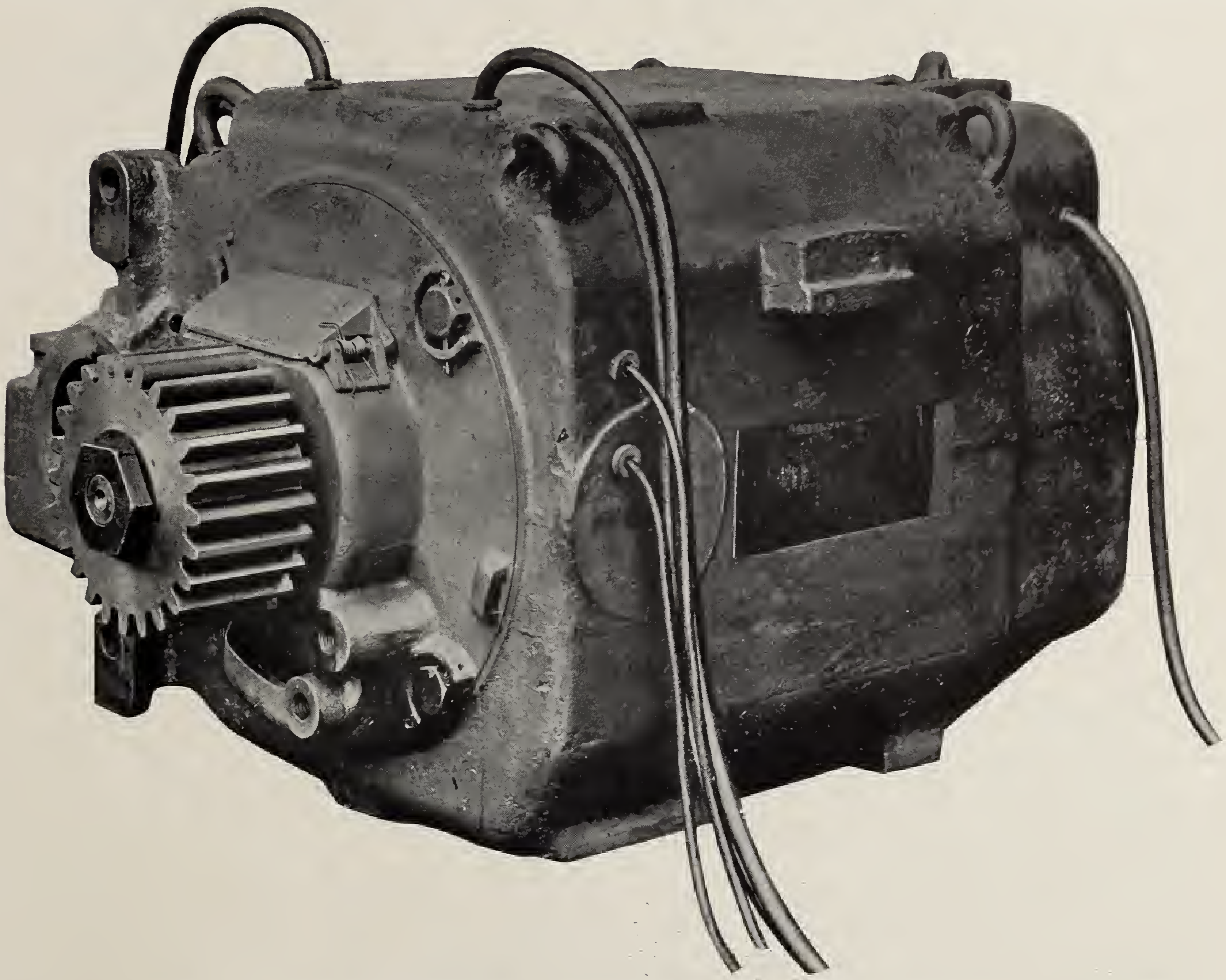
The form of alternating-current trolley adopted for the Ballston line is well adapted to the requirements of steam roads where the local service is taken care of electrically and through passenger and freight service is handled by steam locomotives, pending a complete change to electrical operation. The trolley wire and insulators being off-center are not exposed to the gases of the locomotives, with consequent deterioration, and furthermore, a catenary construction placed off-center can be hung much

lower than a standard center wire without interfering with brakemen on freight cars. A low-running trolley at the side of the car is also preferable in main line operation, as it conforms better to the clearance diagram of such roads without calling for too great a change in height of the trolley wheel or bow. The trolley suspension adopted on the Ballston line, therefore, affords valuable experience with a form of construction adapted to the requirements of electrically converted steam operated lines.

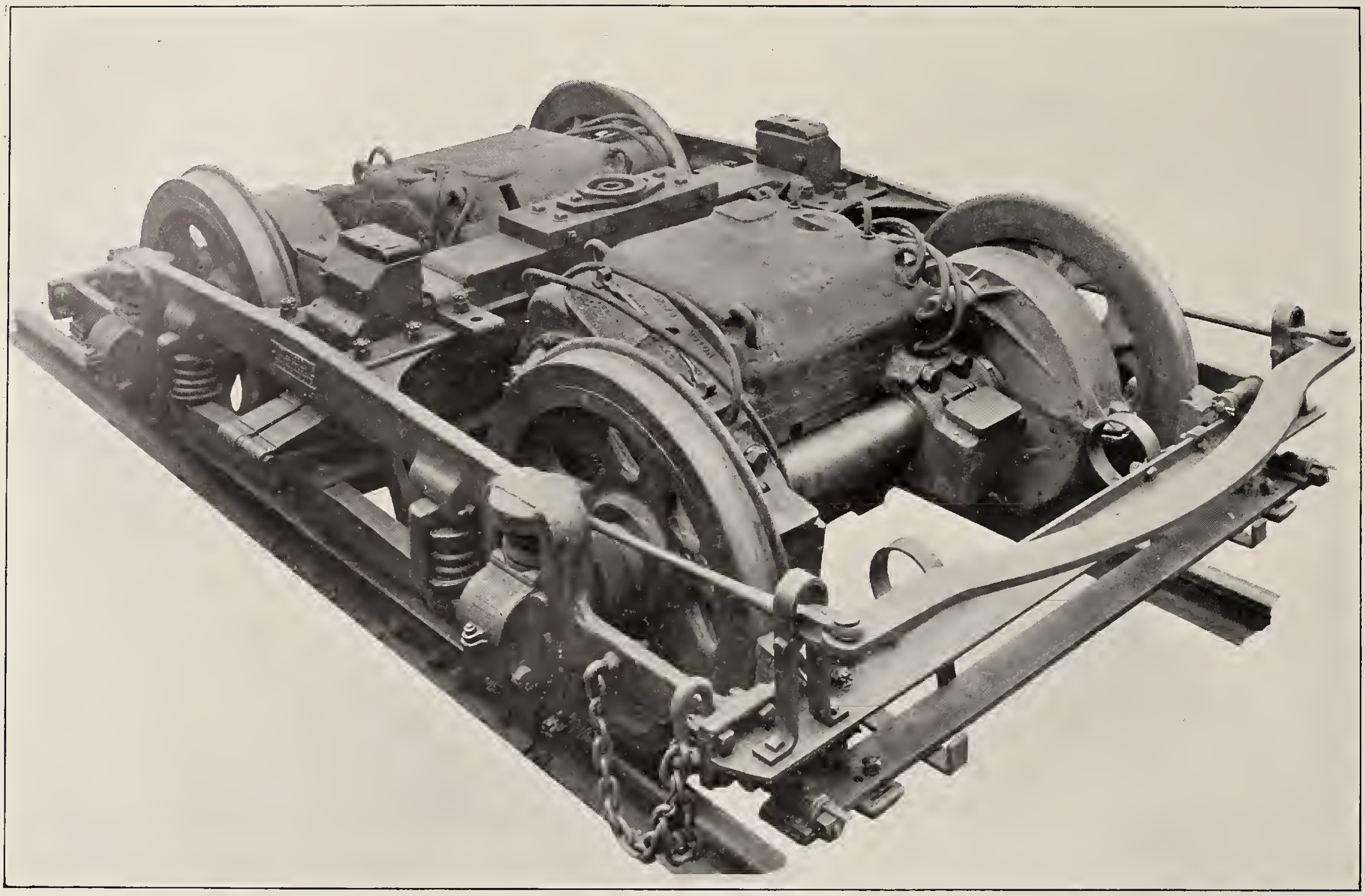
The present sub-station of the Schenectady Railway is temporarily located at Ballston Lake. This sub-station is operated from the distributing system of the Hudson River Power Company, but owing to the fact that this system operates at 40 cycles, it became necessary to introduce a frequency-changing device, and an inverted converter operated from the sub-station direct-current bus bars afforded the most ready means of obtaining 25-cycle current. The permanent sub-station will be erected at Ballston and the inverted converter will be replaced by a motor-generator set, which will give better regulation than can be obtained from an inverted rotary converter. The sub-station feeds directly into the trolley circuit at 2200 volts with no outside transformer sub-stations.

The car equipped with the compensated motors weighs 30.4 tons total without passenger, and is geared for a maximum speed of about 43 miles per hour on level. The car, manufactured by the J. G. Brill Company, has a 32-foot body, is 43 feet over all, and a seating capacity of 44 passengers. The body is mounted upon Brill No. 27 trucks, having 6-foot wheel base, each truck carrying two compensated motors, each motor equivalent to a 50-H. P. direct-current motor, standard railway rating.

The General Electric alternating-current compensated motor consists of an annular laminated iron field with a distributed winding similar to that of an induction motor, and an armature provided with a commutator similar in general mechanical construction to a direct-current railway motor armature. The motors are wound for 200 volts, are permanently connected two in series, and are fed from the 400-volt secondary of an 80-K. W. air blast step-down transformer carried on the car. The distributed character of the field winding fully compensates for the armature reaction, so that power factors are relatively high throughout the range of operation. This type of motor is so designed that at the free running speed of the car, which is the condition most frequently met with in suburban work, the power factor and efficiency are nearly at their maximum values. A high power factor is desirable, as it reduces the capacity and cost of the generating and distributing systems, and more especially effects a material improvement in the regulation of the alternating-current generators. Unlike a direct-current



REAR VIEW OF THE MOTOR. THERE ARE TWO MOTORS ON EACH OF THE CAR TRUCKS. SEE NEXT PAGE



ONE OF THE TWO-MOTOR TRUCKS MADE BY THE J. G. BRILL COMPANY, PHILADELPHIA

system, which has a practically constant potential at the sub-station bus bars, irrespective of the load, the drop in an alternating-current railway system is accumulative up to and including generator and engine regulation. It is desirable, therefore, to maintain as good a power factor as is consistent with good motor design, in order to limit the total drop of the system to a reasonable amount.

All speed-time runs taken on the Ballston line were made over a distance of 1.6 miles on tangent level track at an average speed of 32 miles per hour, or a schedule speed of 29.5 miles per hour, including 15-second stops. The compensated motor equipment has thus demonstrated its ability to make as high schedule speed as any suburban road now operating direct-current equipments under like conditions.

The compensated motors run the car at practically the same speed with 200 volts per motor alternating current and 300 volts direct current.

The operation of the line will be watched by railway engineers with much interest, as its success will demonstrate the fitness of the alternating-current motor for heavy suburban and interurban mixed service. The compensated motor, having demonstrated its fitness for traction work, opens up possibilities in converting main line steam roads which were closed to the direct-current motor and rotary converter combination on the score of first cost and cost of operation.

Vacuum-Tube and Other Electric Lights

SPEAKING of vacuum-tube and other forms of electric lighting in the Electric Power Number of "Cassier's Magazine," Prof. C. P. Steinmetz says:—

"Gases and vapors are made luminous by electrical excitation, either by the electrostatic spark, as in the Geissler tube, or by the electric arc. A spark is made by the passage of an electric current over a gap between conducting terminals through the gas or vapor filling the space. To produce a spark the voltage or electric pressure has to be raised until it breaks down the gap between the terminals. This usually requires a very high voltage, but only a small current. The electric arc is made by the passage of a current across a gap through a conducting vapor bridge formed by the material of the terminals, at relatively low voltage but high current. The arc does not start itself, the vapor bridge having first to be formed, either by jumping a spark across the gap or by bringing the two terminals into contact with each other and then separating them. A bridge of vapor, at the temperature of the boiling point of the material of the material of the terminals, is thereby left behind, which is constantly replenished by evaporation from the terminals. Such an arc may be formed either at atmospheric pressure or in a vacuum. The carbon arc is the hottest of electric arcs, while mercury has such a low boiling point that the mercury arc can be, and is, enclosed by a gas tube.

"Experiments are also being made on the production of luminosity in gases by the electrostatic spark in a partial vacuum, as in the Geissler tube; but the great difficulty seems to be in the high voltage required and the low intrinsic brilliancy of the Geissler tube glow, which requires the use of enormous surfaces to produce sufficient illumination.

"Metal salts introduced in a non-luminous gas flame made it luminous by giving their characteristic metal spectra, as: sodium salts, yellow; lithium, red. Here the luminosity of the metal vapors is probably due to chem-

ical reaction. A much greater brilliancy than that obtained by the use of a gas flame can be secured by introducing such metal salts into a carbon arc, the latter being very much hotter than the former. The best way is to incorporate these metal compounds into the positive carbon thermal, that being the hotter, and, therefore, giving more rapid evaporation. Arc lamp carbons impregnated with metal salts, so-called flame carbons or effect carbons, are now on the market. They give, in addition to the light of the incandescent carbon crater, an additional light from the arc flame, and so an efficiency much higher than the ordinary carbon arc. Their main drawback, however, is that they must be operated as open arcs; they cannot be protected from rapid combustion by an air-tight enclosing globe, since the metal salts produce a smoke or dust which has to be carried off. Such flame carbon arcs, while far more efficient than the ordinary enclosed arc of to-day, are what is called "short-burning;" the carbons have to be replaced or the lamp trimmed every day, while the enclosed lamp needs attention once a week or less frequently. To-day the short-burning, or open carbon arc, has almost entirely been replaced by the long-burning or enclosed arc. Whether the high efficiency of the flame carbon arc will be sufficient to compensate for the short life of the carbons and so reintroduce the open arc, remains to be seen."

The Effect of Electrical Storms on Wireless Telegraphy

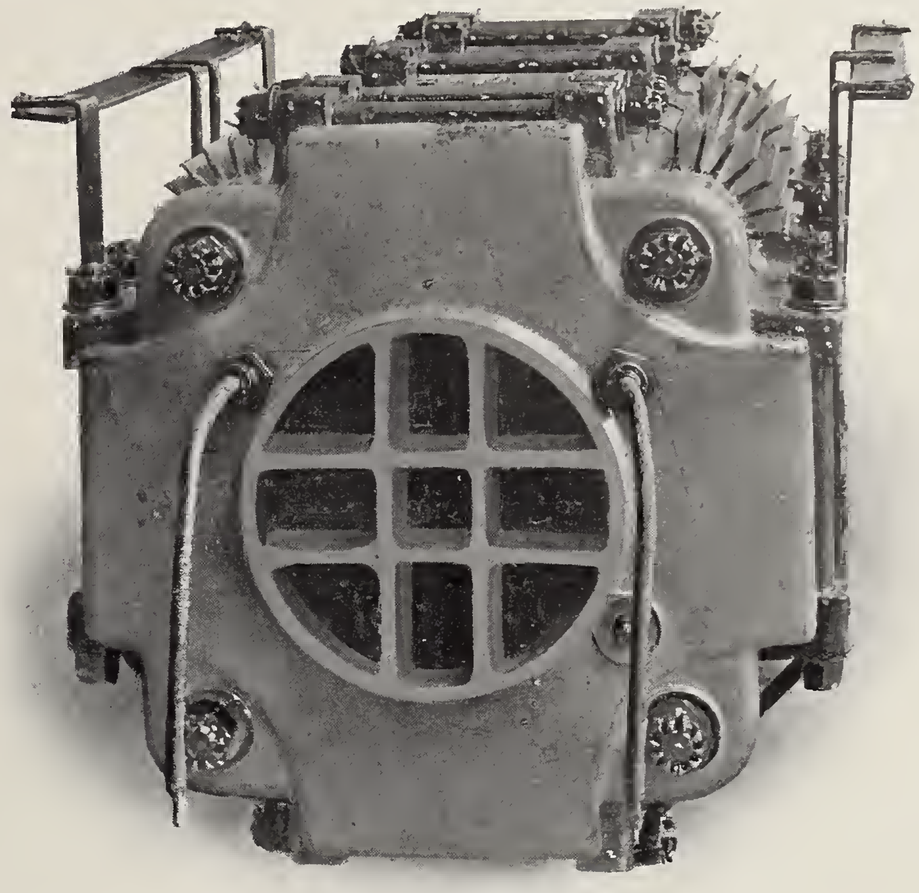
THE effect of lightning discharges on the wireless telegraph, as described by R. G. Blaine in "The Electrical Engineer," of London, is to make a record in the receiver even when no lightning is visible to the observer at the receiving station. The approach of electrical disturbances is usually denoted by the printing of a few dots at intervals on the receiving tape, the most frequent record being three dots, the first being separated from the other two by a slight interval like the letters "e i" in the Morse code, this record being that of distant lightning.

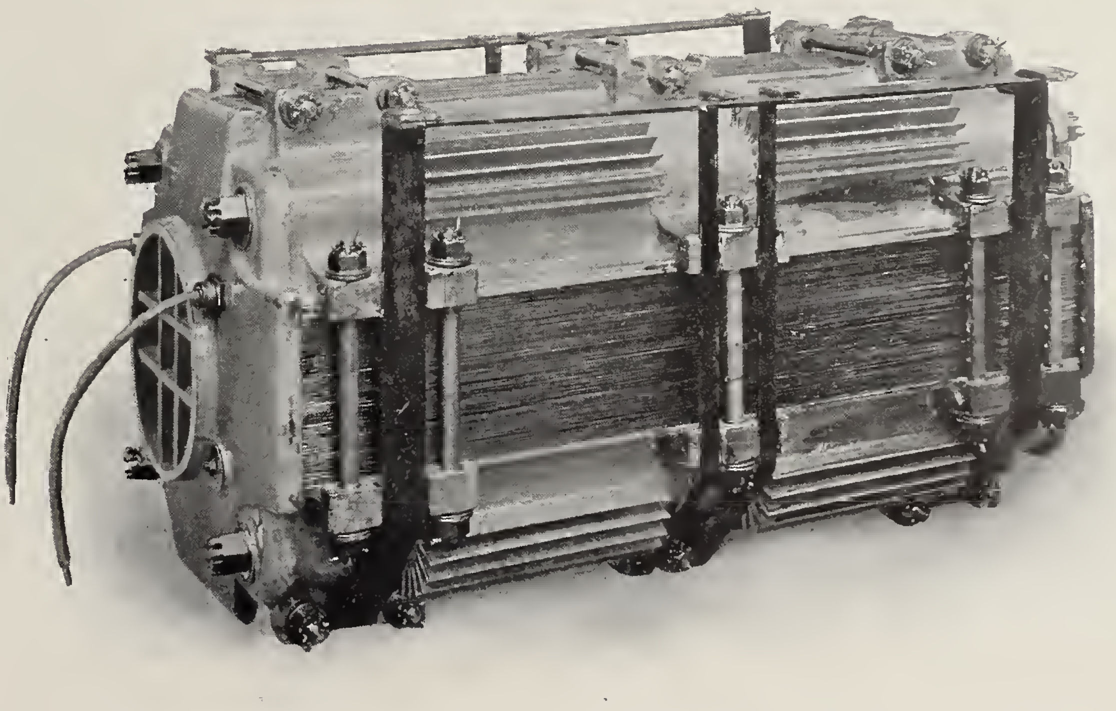
There are other irregular signs—often spelling words on the Morse code—probably due to the same cause. These disturbances are most frequent in summer, and also most frequent near high mountains. They are most frequent at night and between 8 and 10 P. M. When they are present, the distance of successful signalling is reduced by 20 to 70 per cent. as compared with that under the most favorable atmospheric conditions.

Many electrical disturbances or magnetic storms which give rise to severe earth currents, do not affect wireless instruments as these disturbances are apparently oscillations of so long a period as to be altogether outside the range of the wireless apparatus.

A New Railroad Telephone Line

THE New York Central & Hudson River Railroad is constructing a telephone line from New York to Buffalo, which, when connected with a similar line which the Lake Shore & Michigan Southern is putting up between Buffalo and Chicago will give both railroads a through service between Chicago and New York. By an agreement with the American Telegraph & Telephone Company, the latter's instruments will be used, although the lines are being constructed by the two railroads. With the exception of cuts at the principal division points, the line will be an unbroken one. These points are Albany, Syracuse, Buffalo, Cleveland and Toledo. The line will be of heavy copper wire for the entire distance. It is expected to be in operation by fall.





SIDE AND END VIEWS OF THE AIR-COOLED TRANSFORMER USED ON THE CAR. SEE PAGE 189

Power Plant Equipment Notes from the St. Louis Exposition

By D. T. RANDALL

THE boiler plant at the St. Louis Exposition consists of a collection of working exhibits of various boilers arranged according to the ideas of the exhibitors as to the best way to install their apparatus in a modern power plant. Modern coal-handling machinery built by the Link Belt Machinery Company, of Chicago, Ill., serves all the boilers in operation. Run-of-mine coal is delivered in dump cars and is handled entirely by machinery from the cars to the furnaces. Electric motors are used to drive this machinery, which elevates the coal, crushes it to the desired size and distributes it. The arrangement of the boilers necessitates the use of a main conveyor and several cross-conveyors at right angles to the main one. This coal-handling apparatus is not designed to handle the ashes, and these are conveyed in push carts running on tracks in tunnels under the boiler room floor. From these cars the ashes are dumped into the hopper of a bucket elevator outside the boiler house and are elevated into freight cars on a special side track.

Each battery of boilers is equipped with an induced-draught fan driven by by a direct-connected steam engine, by means of which any desired degree of draught may be obtained. The chimney stacks are short, extending but a few feet above the roof.

There are installed sixteen 400-H. P. of Babcock & Wilcox water-tube boilers, equipped with Roney mechanical stokers.

The Cahall Sales Department, of Pittsburg, Pa., have on exhibition four 500 and twelve 400-H. P. horizontal water-tube and three Cahall vertical boilers, making a total of 8000 H. P. exhibited, all of which are equipped with chain grates made, like the boilers, by the Aultman & Taylor Machinery Company, of Mansfield, Ohio.

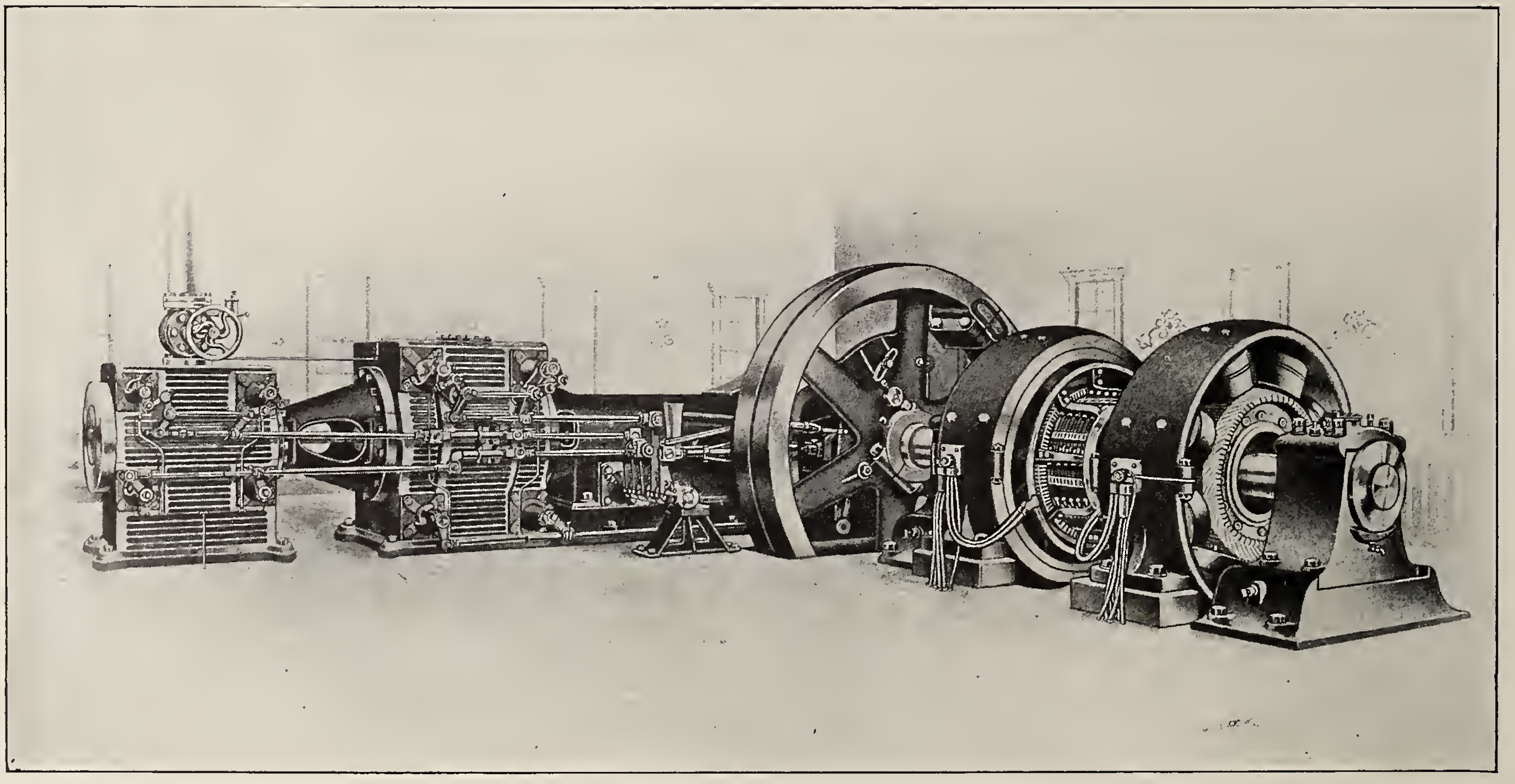
The Heine Boiler Company, of St. Louis, have on exhibition eight 400-H. P. boilers, with Green chain grates. Two Climax water-tube boilers are also exhibited.

The boilers shown by foreign makers contain a large amount of heating surface in a small space and are intended largely for marine use. All are hand fired.

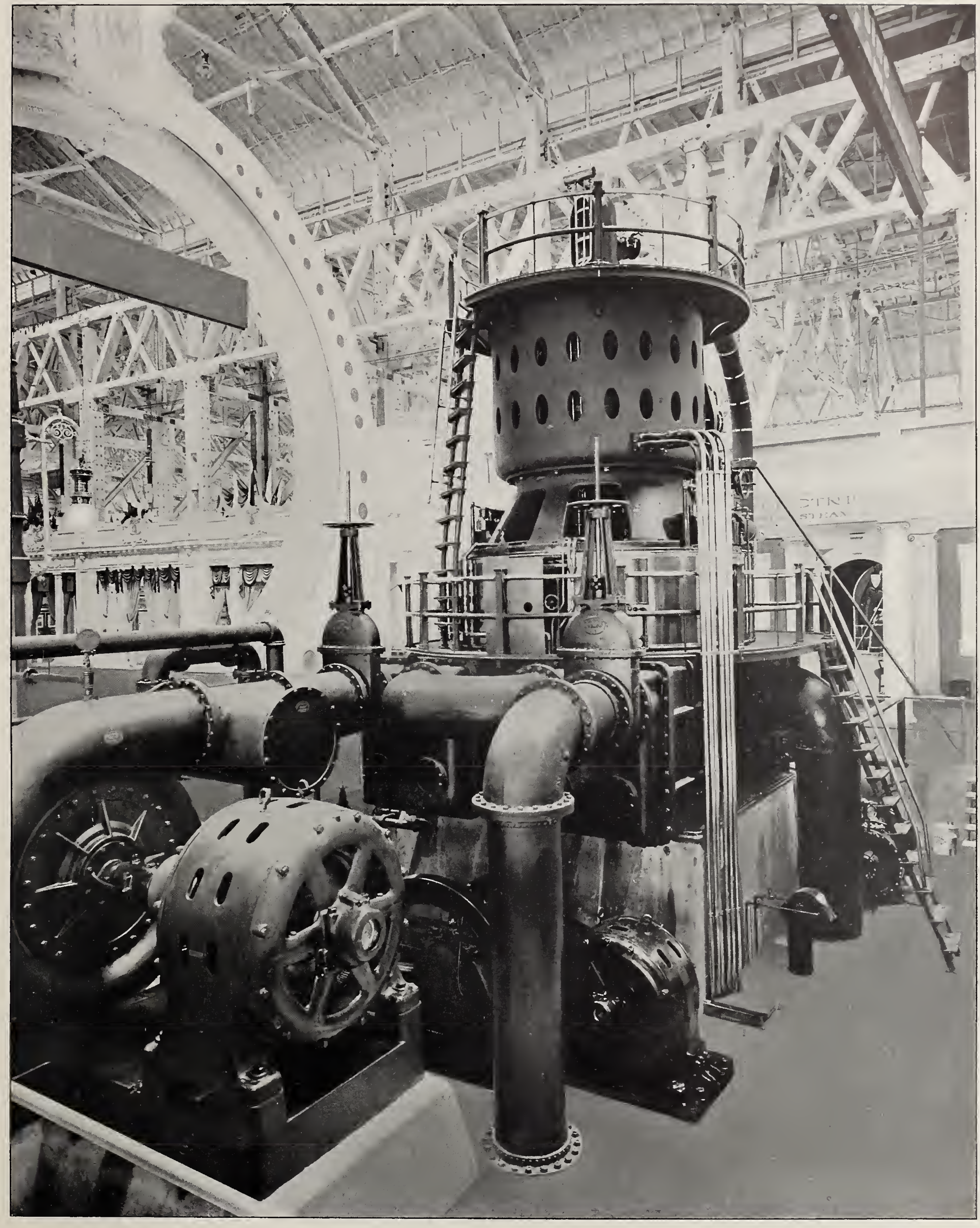
Of these there are three Belleville boilers furnishing steam at 300 pounds pressure to the Belleville engine; two Niclausse boilers, one Schutte boiler and one Duerr water-tube boiler. In Machinery Hall a number of boiler manufacturers have constructed models of their boilers in full-size cross-section.

The steam engines exhibited present a wide variety in design. Some are of interest on account of their size and others on account of some special feature of design. The largest engine shown is the Allis-Chalmers 5000 H. P., direct-connected to a Bullock generator.* This engine is capable of a maximum output of 8000 H. P. In design it is a combined horizontal and

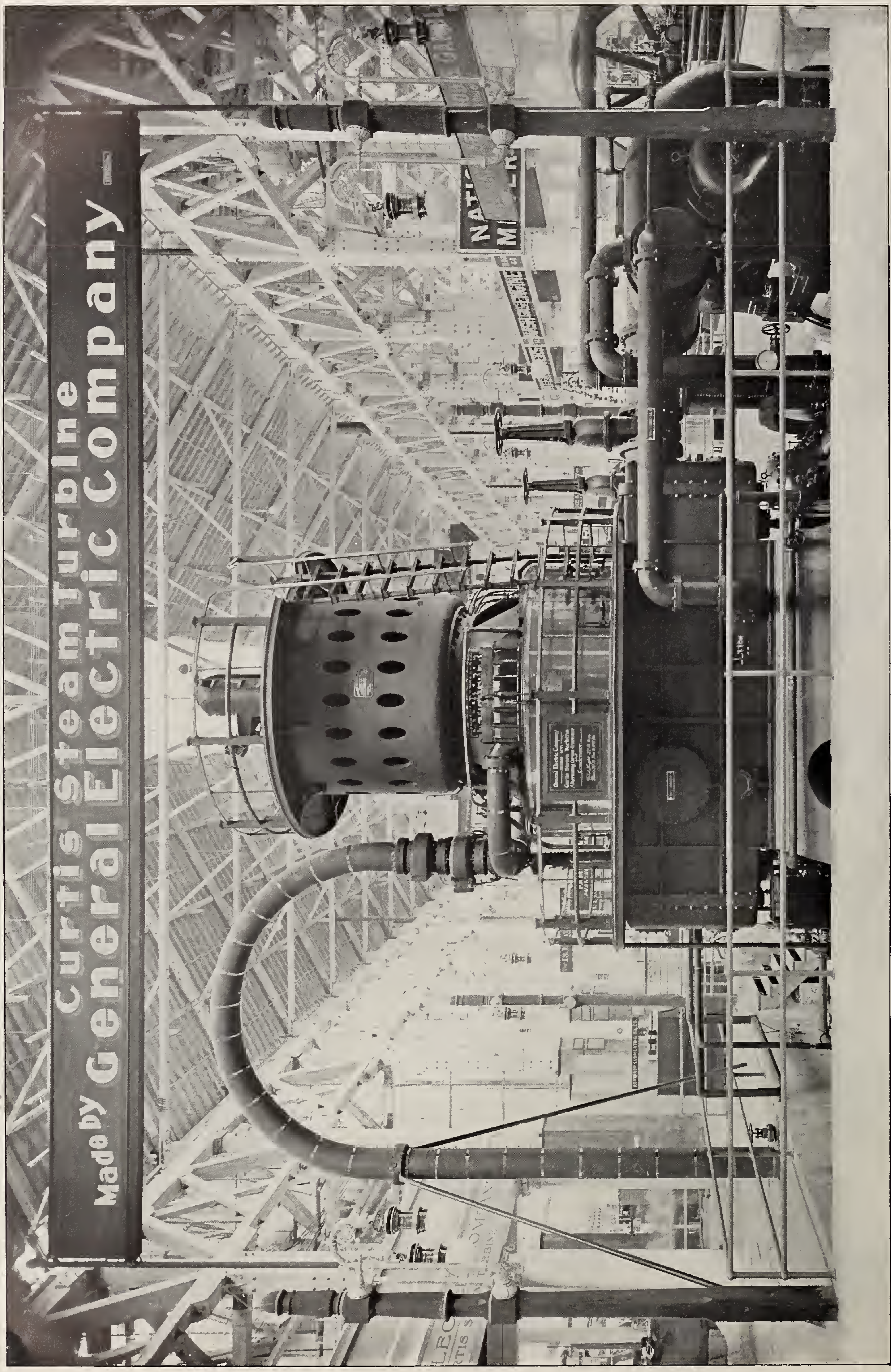
* Illustrations of this and of the Westinghouse steam engines here mentioned were published in the July issue in an article by George H. Barrus, entitled "The Choice of a Steam Plant."



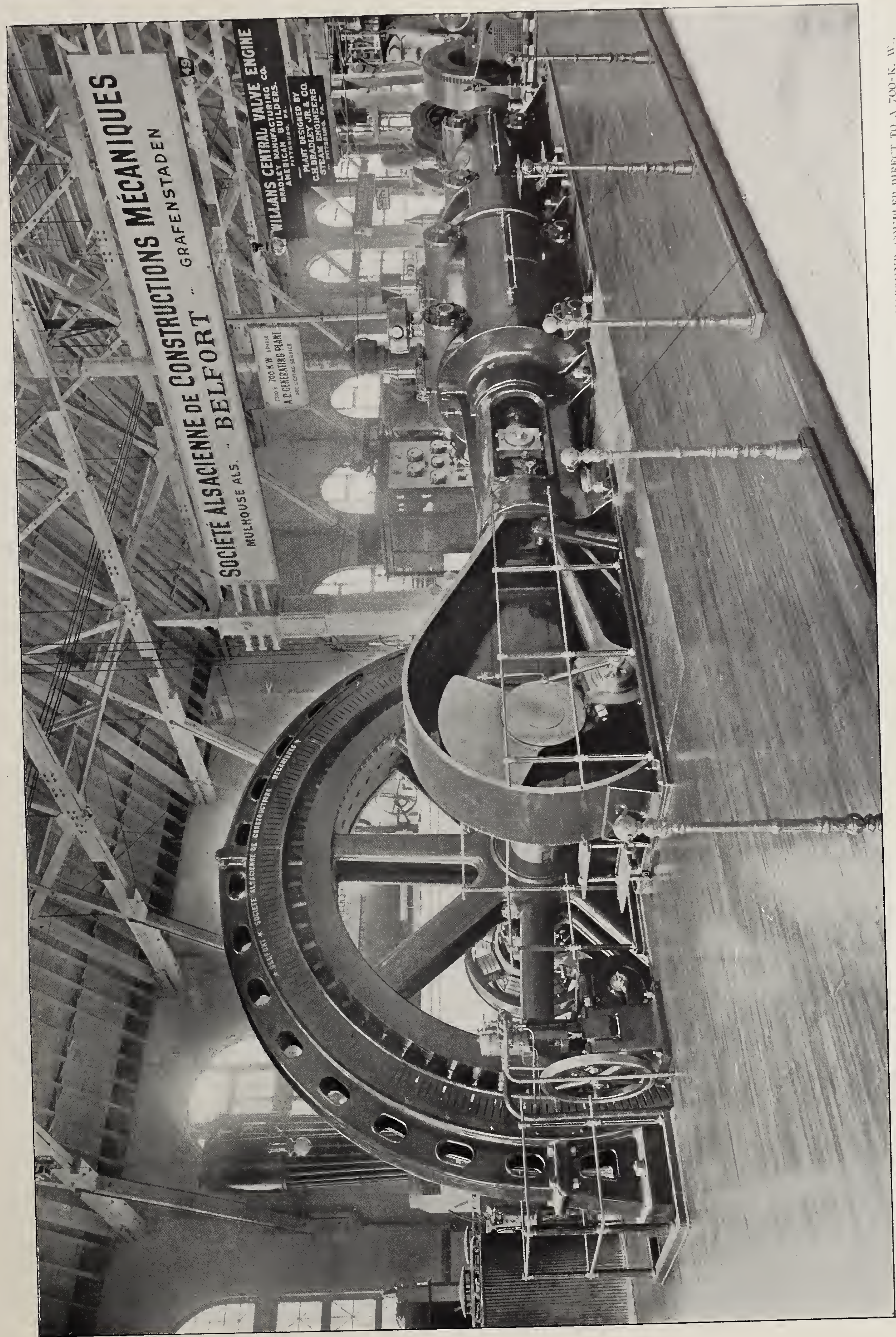
THE HARRISBURG STANDARD TANDEM-COMPOUND FOUR-VALVE ENGINE, DIRECT-CONNECTED STYLE. MADE BY THE HARRISBURG FOUNDRY AND MACHINE WORKS, HARRISBURG, PA.



THE 3000-H. P. CURTIS TURBINE AND GENERATOR SHOWN BY THE GENERAL ELECTRIC COMPANY, OF SCHENECTADY, N. Y.



A FRONT VIEW OF THE 3000-H. P. CURTIS TURBINE AND GENERATOR



A GENERATING SET EXHIBITED BY THE SOCIETE DE CONSTRUCTIONS MECANIQUES, MULHOUSE, ALSACE. THE ENGINE IS OF 1000 H. P., TANDEM-COMPOUND, COUPLED DIRECT TO A 700-K. W., 2300-VOLT, 3-PHASE GENERATOR

THE EXHIBIT OF THE DE LAVAL STEAM TURBINE COMPANY, TRENTON, N. J., AS HERE SHOWN COMPRISES A 30-H. P., 20-K. W. TURBINE DYNAMO; A 20-H. P. ELECTRO-MOTOR CENTRIFUGAL PUMP; A 55-H. P. STEAM TURBINE CENTRIFUGAL LOW-PRESSURE PUMP; AND A 58-H. P. STEAM TURBINE CENTRIFUGAL HIGH-PRESSURE PUMP

EXTERIOR OF THE DE LAVAL STEAM TURBINE COMPANY'S BUILDING AT THE ST. LOUIS EXPOSITION

vertical engine having the high-pressure cylinder horizontal and the low-pressure cylinder vertical. Their diameters are 44 inches and 94 inches, and the stroke is 60 inches. This engine is 39 feet long, 39 feet high and weighs 720 tons. It exhausts through a 36-inch pipe into an Alberger condenser. The generator is rated at 3500 K. W., and when running at 75 revolutions per minute delivers a three-phase current of 25 cycles at 6600 volts. It furnishes current for illumination at night and for power during the day.

In point of capacity the Westinghouse Machine Company are in the lead, having four 2900-H. P. vertical cross-compound engines, direct-connected to 2000-K. W. generators, and also a number of small engines for driving centrifugal pumps for condensers, cooling towers, etc.

The Hooven, Owens, Rentschler Company, of Hamilton, Ohio, are operating a 3500-H. P. engine of the vertical cross-compound type, direct-connected to a 2250-K. W. generator made by the National Electric Company, of Milwaukee, Wis.

The Buckeye Engine Company, of Salem, Ohio, show an exceptionally quiet running engine of 1500 H. P., direct-connected to a Crocker-Wheeler generator, which furnishes power to the Intramural Railway.

The Lane & Bodley Company, of Cincinnati, Ohio, have in operation a 900-H. P. horizontal cross-compound engine, direct-connected to a Crocker-Wheeler generator. This engine has a simple valve gear of the Corliss type, but without wrist plate.

The Fleming engine shown by the Harrisburg Foundry and Machine Company, of Harrisburg, Pa., is tandem-compound, of 600 H. P. capacity, and is direct-connected to a Crocker-Wheeler generator, running at 150 revolutions per minute. The valves are of the Corliss type, driven by four eccentrics through specially designed bell cranks, giving them a positive motion. The cylinder diameters are 15 inches and $40\frac{1}{2}$ inches, giving a ratio of volumes of 1 to 7 1-3. A large reheater and a condenser are installed with the engine. Results of tests on an engine of the same size show the steam used to be a little less than 13 pounds per indicated horse-power.

A Greenwald engine, made by the I. & E. Greenwald Company, of Cincinnati, Ohio, is cross-compound, direct-connected to a 400-K. W. generator, and furnishes current to charge the electric launches.

The Brown-Corliss Engine Company, of Corliss, Wis., show two 750-H. P. vertical cross-compound direct-connected engines of the Corliss type, which are running at the exceptionally high speed of 135 revolutions per minute.

A Willans central-valve triple-expansion engine of 1000 H. P. capacity, running at 277 revolutions per minute, is exhibited by C. H. Bradley & Co., of Pittsburg, Pa.

The Delaunay-Belleville quadruple expansion engine is to be operated on steam at 300 pounds pressure furnished by the Belleville boilers located in the boiler house. This engine has six cylinders in which steam is so distributed as to secure quadruple expansion. It is of 1500-H. P. capacity, runs at 333 revolutions per minute, and is direct-connected to an alternating-current generator.

The Mulhausen engine is tandem-compound. A gear driven shaft at right angles to the main shaft operates the valves. The admission valves are of the piston-grid iron type. The generator which it drives is a 700-K.

W., three-phase, 2300-volt machine, direct-connected. The engine is exceptionally well furnished, but is evidently of too expensive construction to find favor in the American market.

All of the above engines are designed to operate condensing, and are provided with suitable apparatus, made by a number of different manufacturers.

Four makers of steam turbines are represented. The Westinghouse Machine Company have one of their standard 400-K. W. turbine sets installed, and it is their intention to run it without a shut-down until the Exposition closes. Its speed is 3600 revolutions per minute.

The General Electric Company are operating a 3000-H. P. Curtis turbine and generator, running at 750 revolutions per minute.

The American De Laval Steam Turbine Company have an exhibit in the Mining Gulch. The main feature of their exhibit will be the operation of high-pressure centrifugal pumps to show their adaptability to placer mining.

One of these pumps is capable of delivering 250 gallons of water per minute against a head of 700 feet. This pump is driven by a direct-connected turbine of 58 H. P. capacity. Two other pumps and a 20-K. W. direct-connected generator are also shown.

The Hooven, Owens, Rentschler Company, of Hamilton, Ohio, are installing a steam turbine in the space adjacent to their other engine exhibit. This turbine is known as the Hamilton-Holcwarph, and is direct connected to a Bullock generator of 1000-K. W. capacity. The speed is 1500 revolutions per minute. This, being a new turbine in the market, is attracting a good deal of attention.

In point of numbers, the oil and gas engine exhibits of large units are a disappointment. No large foreign gas engines are shown, and those of American manufacture are comparatively small. Of small gas and gasoline engines there is a goodly number.

Of the larger engines exhibited the 280-H. P., three-cylindered vertical Westinghouse engine at the United States Geological Survey Coal Testing Plant, to be operated on gas furnished by a Taylor gas producer made by R. D. Wood & Co., of Philadelphia, will be of the greatest interest to engineers, because of the fact that experiments will be made to produce a suitable gas from bituminous and lignite coals from various parts of the United States. If it can be demonstrated that there is an apparatus on the market which will successfully and economically utilize Western coals for gas engine work, it will mark a great advance in power plant practice.

The Westinghouse Company are also exhibiting in Machinery Hall a 250-H.P., two-cylinder, double-acting gas engine, direct connected to a generator. This engine is built on much the same lines as the large foreign engines, but it has the regular Westinghouse governing mechanism and special stuffing boxes designed to meet the severe service to which they are subjected in a double-acting gas engine. The parts are well protected from high temperature by water jackets. The pistons and piston rods are designed to provide for a circulation of water through them. This engine will operate with city gas.

Another interesting engine exhibit is the power plant of the "Tyrolean Alps." For the purpose of furnishing light and power for this concession, three 225-H. P. Diesel engines, direct connected to three Bullock generators, have been installed. Crude oil from Lima, Ohio, costing about 4 cents per gallon, is being used, and the makers of the engines guarantee, with oil at this price, to produce a kilowatt-hour for $4\frac{1}{2}$ mills at full load. These engines occupy a floor space of about 9 x 17 feet, and are 12 feet high. Each has three cylinders, 16 x 24 inches, and runs at 160 revolutions per minute.

Air in the cylinders of the engines is compressed to 500 pounds per square inch. The oil is admitted at the proper point of the stroke in a fine spray produced by air compressed to 900 pounds per square inch. The temperature of the air in the cylinder is such that the oil instantly ignites and burns during admission, which continues about one-third the stroke. The amount of oil used varies with the power required, and is regulated by the governor. Two motor-driven, two-stage air compressors furnish compressed air for the oil spray. The oil supply is stored in a tank located a little above the admission valves.

The Weber Gas and Gasoline Engine Company, of Kansas City, Mo., are operating a 75-K. W., direct-connected gas engine and generator on gas made in a suction gas producer burning charcoal. This is a type of apparatus for which there is a demand in Mexico and other localities where wood is plentiful and coal is expensive.

Messrs. R. D. Wood & Co., of Philadelphia, have erected a 400-H. P. capacity gas producer in the main boiler house, and will furnish gas to a number of gas engines exhibited in Machinery Hall.

A Novel Method of Operating Telephones

FOR efficient service and novel methods of operating, says "The Cumberland Telephone Journal," the native half-breed employees of the exchange in Manila are certainly without equal.

An American gentleman in that city wished to call up some one on an important business matter demanding immediate attention. For fully half an hour he rang steadily, until some friends happened to come in. Asking one of the gentlemen to keep up a steady ringing, he jumped into his carriage and drove over to the exchange.

In less than ten minutes his voice came over the wire, and in language not exactly parliamentary he told of finding the operator lying back in his chair reading a paper and smoking, with his feet on the table, one bare toe keeping the drop of the line up, while he used the other foot to replace any other drops that might fall.

During the night the operators have the habit of grounding or opening a line that is at all likely to be busy; in fact, during the night hours the wires of the "Cablenews" and "American," Manila's two principal daily newspapers, are frequently cut off for hours at a time.

A feed wire on the Lowell division of the Boston & Northern Street Railway line in Hudson dropped across the railroad track recently and proved strong enough to stop a freight train, which was going at the rate of 12 miles an hour on an up grade. The wire had sagged sufficiently to catch the locomotive just below the headlight. Poles for almost half a mile were ripped up and a house which stood near the track was lifted on one side several feet in the air by the cable, drawn taut in front of the train. The train was brought to a standstill with the locomotive wheels revolving on the rails. Steam was shut off and the train backed up to release the wire.

Japan is an excellent market for American electrical machinery and instruments, as shown by consular and other reports. Electrical instruments last year were exported to Japan to the value of $26,781, and electric machinery sent to the little island empire reached a total valuation of $70,592. These amounts may not seem large, but considering the condition of the country last year, and its gradual opening to the influences of American ideas, the exports of electrical goods showed gratifying encouragement.

Testing Alternating-Current Generators

By B. A. BEHREND, Chief Engineer of the Bullock Electric Manufacturing Company

A Paper Presented to the International Electrical Congress at St. Louis, September 12-17

THE starting point of improvement of engineering apparatus is an exact knowledge of its properties. It is only after learning the characteristics of a machine that we are placed in a position to judge where improvement is necessary, and how it can be accomplished. In order to know whether improvements have been effected, it is essential to possess some methods of testing which furnish a criterion of whether the improvement is real or imaginary. The numerous claims of inventors describing improvements in electrical apparatus are rarely put to test, and many of these improvements are fabrics of the inventor's imagination rather than actual improvements.

It is thus that the aim of the engineer whose work consists in designing and creating new apparatus is directed towards means for the accurate determination of the characteristics of his machines, and improvements in the methods of testing are hence synonymous with improvements in the apparatus itself.

The design of alternating-current machinery has been a slow process of evolution. At first a subject dark and poorly understood, sound theory and experiment have lighted it up so that from the uncertain groping in the dark, the design of large power units has become a matter of scientific calculation based on a vast amount of empirical data gathered from careful and elaborate tests, generally made under difficult circumstances, with care, devotion, and sacrifice on the part of the engineers, which are a credit to, and an ennobling feature of, the engineering profession.

The subject of this paper is a description of an improved method devised by the author for testing alternating-current generators and synchronous motors, under full-load conditions, without actually having to place the machines under full load. It is not possible with the large sizes of units of the present day to supply the driving power for test required at full load and at over load, and, therefore, methods of test have been devised in which the driving power is limited to the power available in the shops of the manufacturer. The machines must be put under conditions such as lead to full losses in the core and the coils of the machines.

The alternating current, by means of its property of being able to store energy during one-quarter of a period, and return it during the next quarter, allows the flow of large amounts of apparent energy in the form of so-called wattless currents. It is possible, by properly exciting two alternating-current machines operating in parallel, to circulate a large quantity of apparent energy without having to supply more true energy than corresponds to the losses which take place in the machines. Such motor-generator tests, consisting in operating one alternating-current machine as a motor, running idle, have been made by the author for many years, and have been used for the determination of the regulation of alternators on low power-factors, as well as of the heating under the same conditions.

But this method of testing requires two machines of the same capacity and involves the expenditure of power corresponding to the losses of two machines. The first to suggest the circulation of power within a single

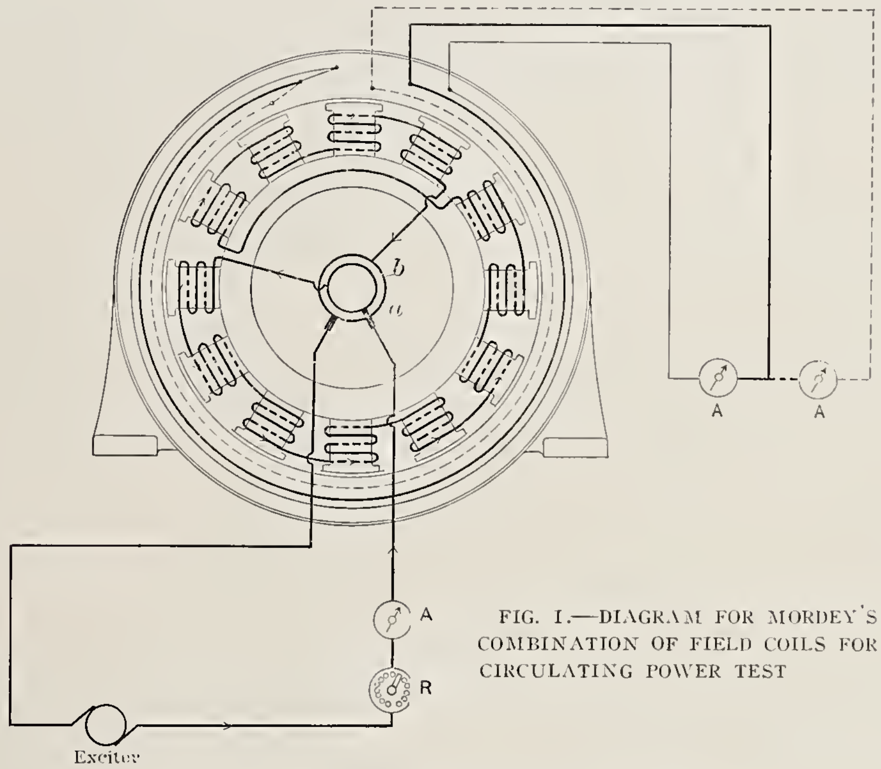


FIG. I.—DIAGRAM FOR MORDEY'S COMBINATION OF FIELD COILS FOR CIRCULATING POWER TEST

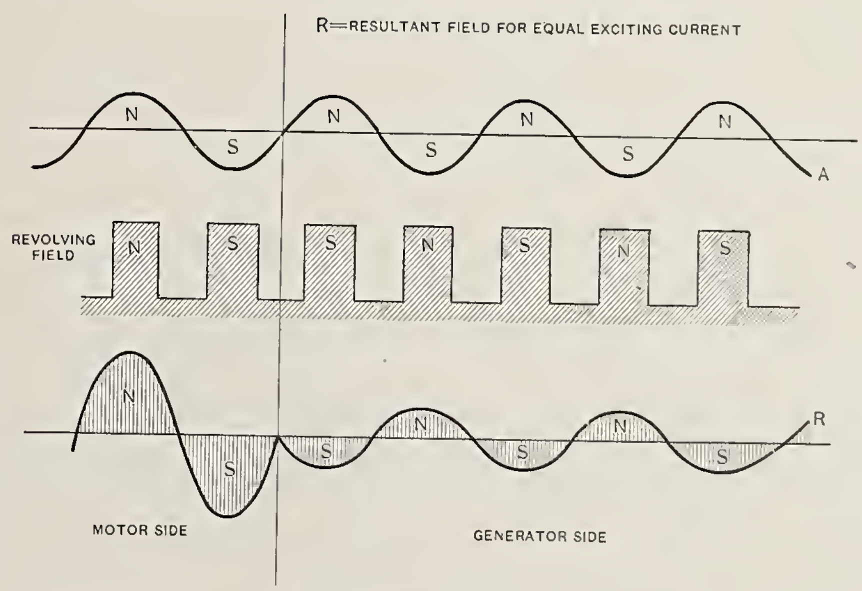


FIG. 2.—DIAGRAM SHOWING EFFECTS OF ARMATURE CURRENTS IN MORDEY'S TEST

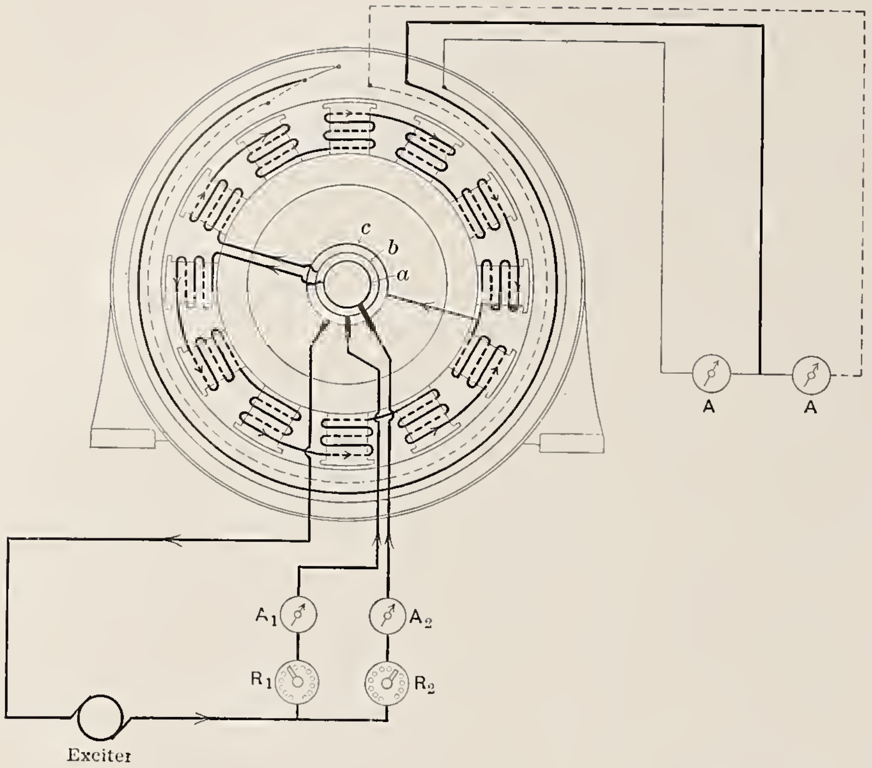


FIG 3.—DIAGRAM FOR THE AUTHOR'S COMBINATION OF FIELD COILS FOR CIRCULATING POWER

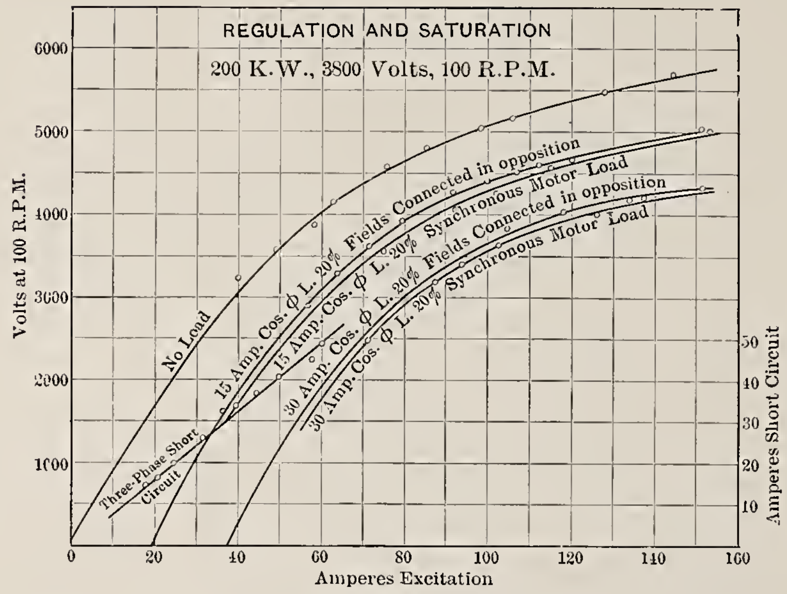


FIG. 5.—COMPARISON BETWEEN REGULATION CURVES OBTAINED BY SYNCHRONOUS MOTOR-GENERATOR TEST BY THE AUTHOR'S METHOD

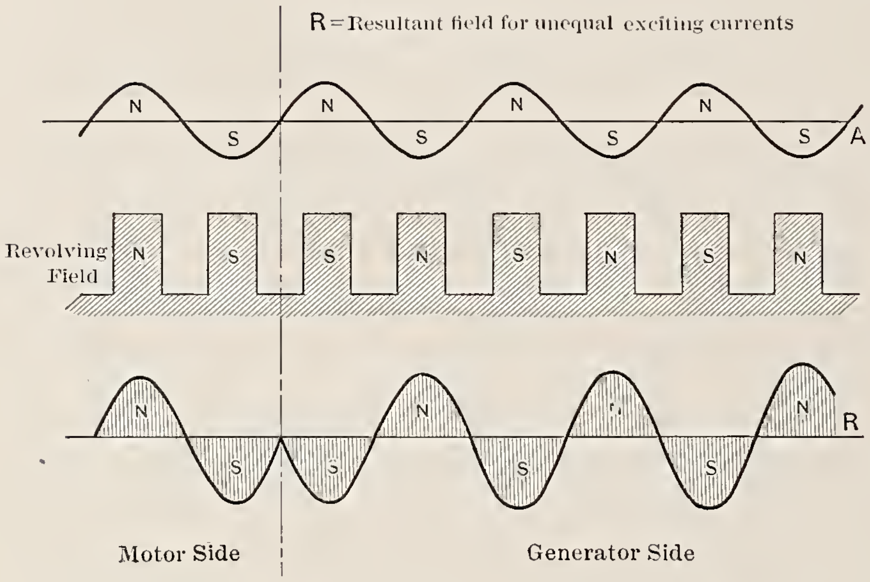


FIG. 4.—DIAGRAM SHOWING EFFECTS OF ARMATURE CURRENTS IN THE AUTHOR'S SPLIT-FIELD TEST

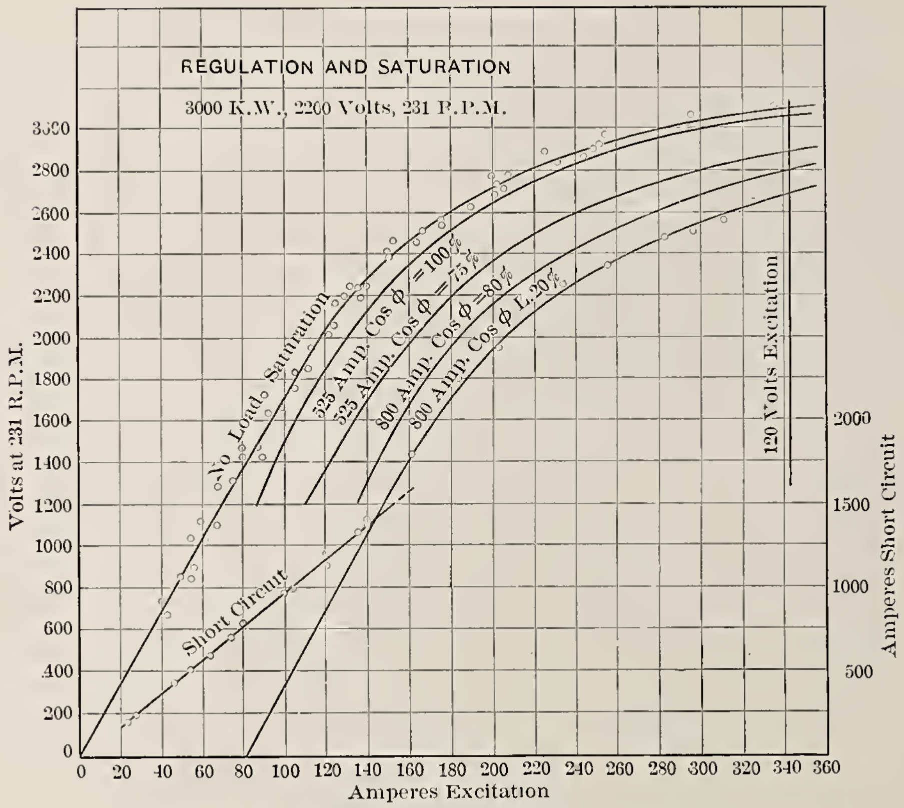


FIG. 6.—REGULATION CURVES OBTAINED FROM A 3000-K. W. ALTERNATOR BY THE AUTHOR'S METHOD

machine was Mr. William M. Mordey in a paper, Volume II, 1893, of the Journal of the British Institution of Electrical Engineers. Mr. Mordey's method applied, for instance, to a single-phase generator, having twenty poles on each side of a single exciting coil, would be carried out by splitting the armature into two sections of eight and twelve coils respectively, and by connecting these sections in opposition so that only four coils would be effective in regard to the circulation of current through the armature. The section of the armature which contains eight coils acts as motor, while the section containing twelve coils acts as generator. The current which circulates through the armature coils is almost in quadrature with the resultant e. m. f., and is, therefore, a wattless current. Hence, the eight poles of the motor section of the machine will be strengthened by the armature current, whereas the twelve poles of the generator section of the machine will be weakened by the same current. This leads to a magnetic unbalancing of the machine, as the motor fields carry more resultant flux than the generator fields. In Mordey's machine, this condition may not have caused trouble, as his machine does not contain iron in the armature; but in modern generators his method cannot be used on account of the magnetic unbalancing of the machine. Instead of dividing the armature into two sections and connecting these sections in opposition, it naturally suggests itself, especially on polyphase machines of the revolving-field type, to split the field into two sections and to connect these sections in such a manner that the e. m. fs. induced in the armature are in opposition. This method cannot be carried out in practice, as the machine vibrates and jars in a manner which makes its operation under such conditions impossible.

Referring to Fig. 1, which represents Mordey's combination of field coils, we see that the current in the armature strengthens the field of the poles which act as motor and weakens the field of the poles which act as generator, as represented in Fig. 2. The magnetic attraction between the revolving and stationary parts being proportional to the square of the induction in the air-gap, we see at a glance from Fig. 2 that the conditions of operation are impossible, on account of the unbalanced magnetic forces. In order to circulate power

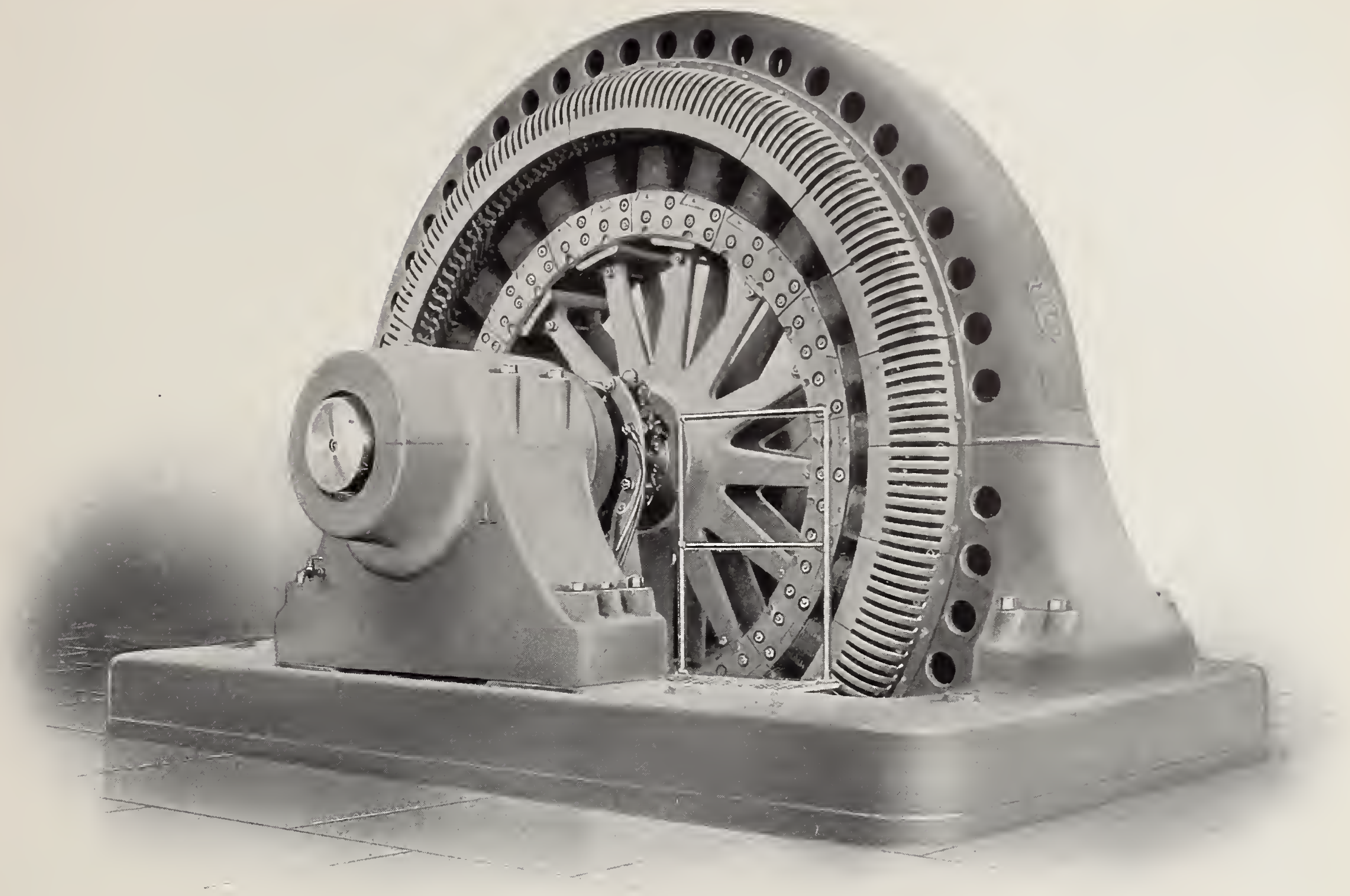


FIG. 7.—A 3000-K. W. BULLOCK ALTERNATOR

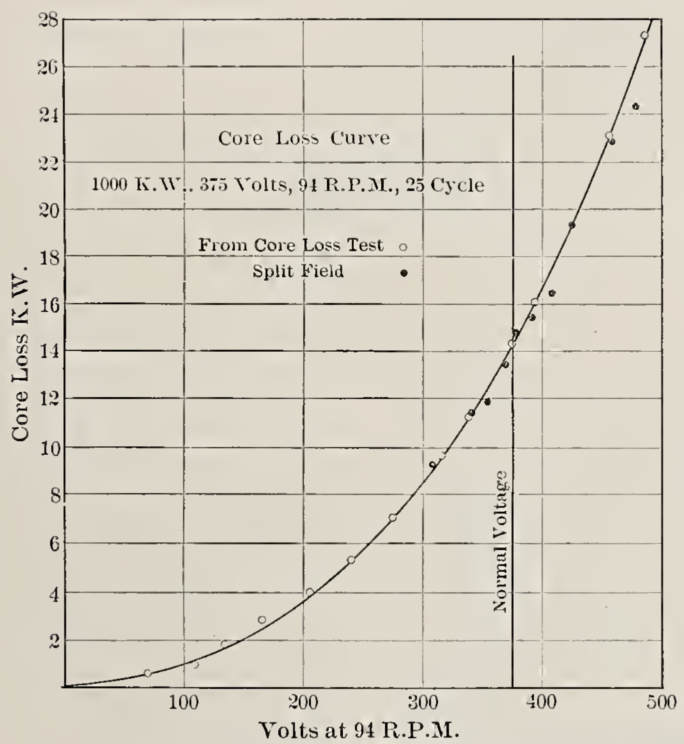


FIG. 8.—COMPARISON OF CORE LOSSES OBTAINED ON OPEN CIRCUIT AND IN THE AUTHOR'S SPLIT-FIELD TEST

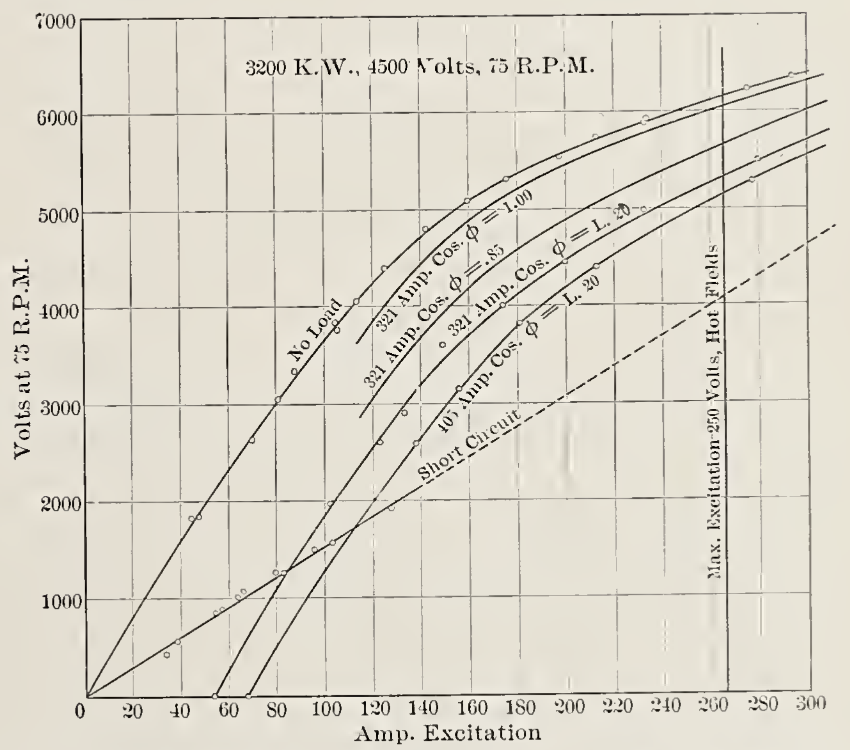


FIG. 9.—REGULATION CURVES ON A 3200-K. W. ALTERNATOR OBTAINED BY THE AUTHOR'S METHOD

successfully within a single machine, it is thus essential to obtain uniform induction in the air-gap of both the motor and the generator poles. As the armature reaction strengthens the motor poles and weakens the generator poles, the impressed excitation of the motor poles must be smaller than the impressed excitation of the generator poles, and this can be effected as shown in Fig. 3, by splitting the field coils into two sets of an equal number, excited with different field currents. Fig. 4 shows the effect of the armature reaction on the poles. Both in Figs. 2 and 4 the wavy line A represents the field produced by the armature current alone, and the wavy

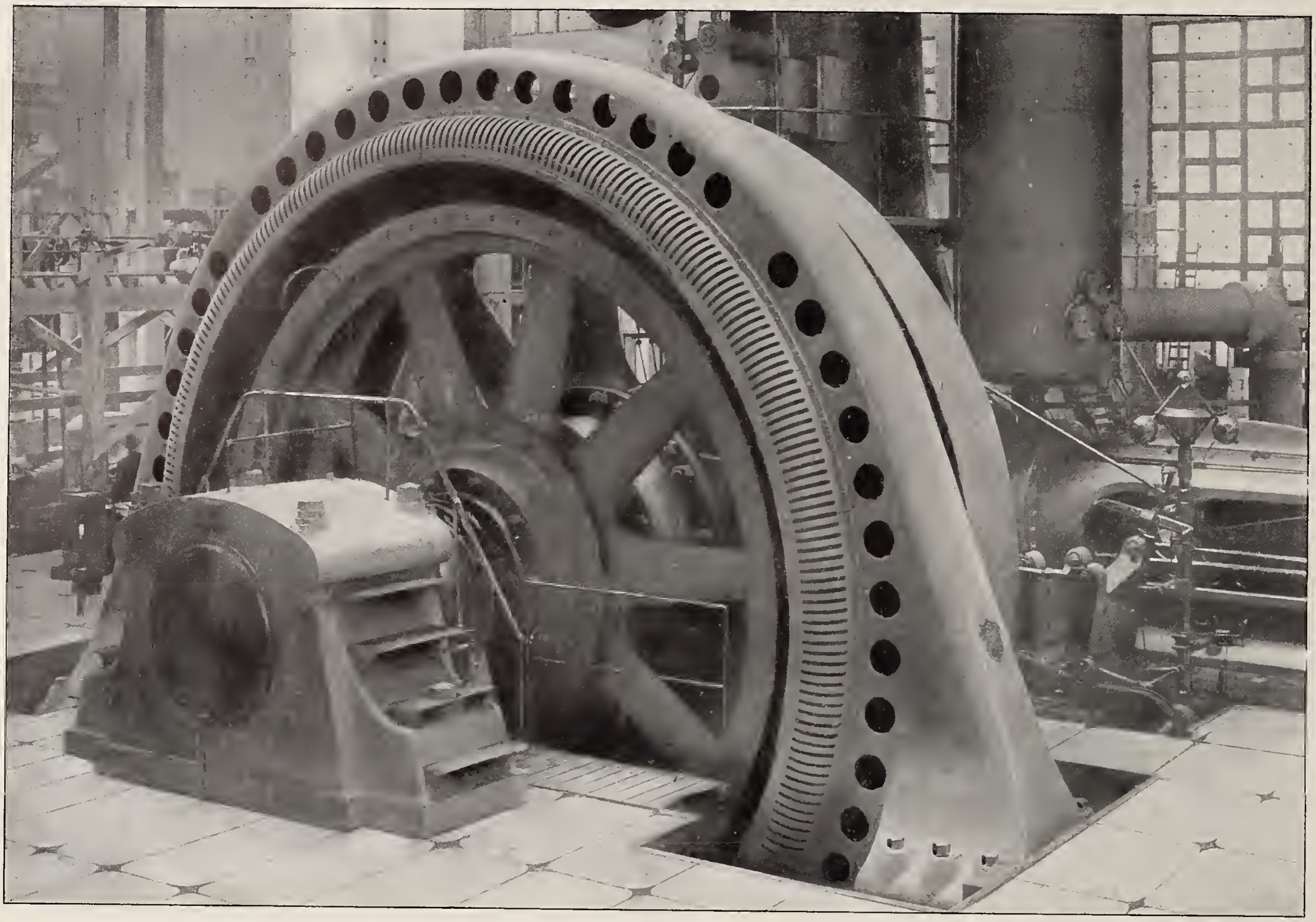


FIG. 10.—A 3500-K. W. ALTERNATOR

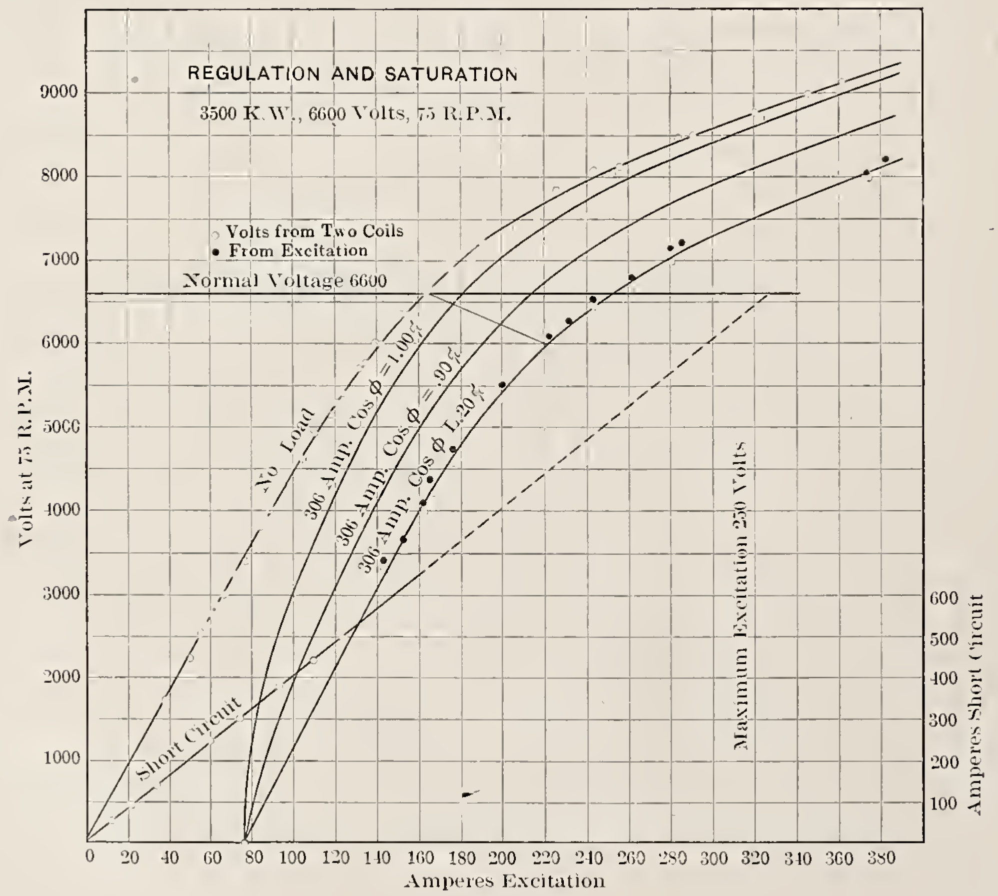


FIG. 11.—REGULATION CURVES OBTAINED BY THE AUTHOR'S METHOD FROM A 3500-K. W. ALTERNATOR

line R represents the resultant magnetic field.

Fig. 5 represents the regulation curves on low power-factor obtained by first running a synchronous motor from the generator and secondly by circulating power within the machine itself. The agreement between the two methods is very satisfactory. Numerous experiments have been made on machines designed by the author to check the new method against the synchronous motor-generator tests, and the results have shown a very close agreement.

Fig. 6 shows the regulation curves of a 3000-K. W., 26-pole, 50-cycle generator, obtained in this manner. Fig. 7 shows an illustration of this machine. Fig. 11 shows the regulation curves of a 3500-K. W., 40-pole, 25-cycle generator, supplying power to the World's Fair at St. Louis, and illustrated in Fig. 10. Fig. 9 shows the regulation curves of a 3200-K. W., fly-wheel type, 96-pole, 60-cycle generator. The terminal voltage corresponding to the conditions under which the machine is operating in the test can be determined either by measuring the volts on a set of coils per pole multiplied by the total number of coils, or by adding to the excitation

on the motor fields the excitation required to drive the armature current through the armature winding. Both methods have invariably given the same results.

DETERMINATION OF HEATING

Numerous tests have been made to ascertain the actual losses in operating the machine in the manner described by splitting the field. Fig. 8 shows the comparison between the core loss of the machine, as determined in open circuit run, with losses as obtained in the split-field test. These tests were carried out on a 1000-K. W., 25-cycle, 32-pole generator.

The heat runs obtained by this method on the machine represented in Fig. 10 and on a 3200-K. W. machine, at full normal load in kilo-volt-ampere and power-factor-zero, yielded the following results:—

HEATING TEST

		3500-kw.	3200-kw.
Volts		6600	4500
R. P. M.		75	75
Frequency		25	60
Hours		18	23
Load K. V. A.		3500	3870
Temperature Rise Degrees Centigrade	Armature Surface	30°	27.5°
	Armature Coils	34°	31.5°
	Field Coils	34°	31.5°

It is hard to imagine a simpler method of testing than the new method described. The course of evolution in engineering has always been from the complex towards the simple. It has taken many years to evolve this method of testing which enables us to obtain with comparative ease the most important data of the performance of alternating-current generators. The only drawback of the method consists in the fact that it is applicable only to machines having a comparatively large number of poles. It has not been successfully applied to machines having fewer than eight poles. The application of this method is confined to machines of the slow-speed type, and with the advent of the steam turbine generator, new methods will have to be devised to produce artificially full-load losses without the expenditure of full-load power.

Storage Battery Electrolyte

THE importance of having a suitable electrolyte for use in storage batteries is emphasized by Mr. J. Kershaw, in a letter to "The Electrical Review," of London.

It is thought sufficient, he says, to order "sulphuric acid for storage batteries"—in some instances brimstone-made acid is stipulated—for filling the cells, but the writer's experience, which has covered all the different batteries now before the public, has convinced him that such specification is not sufficient. Makers of acid will not guarantee the suitability of their acid for use in batteries, because they cannot tell what is the quality of the other material used in the construction of the batteries, and any fault that may afterwards appear is at once put down to the acid.

In a lot of cases the acid is absolutely unfitted for electrical purposes; in other cases common tap or tank water has been used for breaking down acid that may be otherwise suitable, and very often the materials which are used for constructing the plates, cells and other parts, contain impurities, or unsuitable substances, which the acid soon corrodes, and the battery is destroyed.

Sulphuric acid, even when it is the best brimstone made, contains impurities or noxious elements which render it unsuitable for the purpose, unless especially prepared and tested. This is where the Continental accumulator makers are superior to the English makers, as they not only test everything, but when they find a suitable material, whether it be acid, lead, or the hundred and one things which go to make an accumulator, they use only that article, even if the use of it means that they have to pay more.

The Continental makers are very particular that the quality of acid they use is up to a very strict standard which they have laid down, and they will go to the expense and trouble of sending an acid that passes their specification over long distances at a great cost for carriage, rather than run the risk of spoiling a battery by using acid that does not come up to their standard of quality.

Not so with the English makers; in fact, several of them take the quality of the acid for granted, no matter where they buy it. Some makers of batteries do not know the difference between pyrites acid, acid made from recovered sulphur, and acid made from the best Sicilian brimstone; to them they are both sulphuric acid and are both suitable. There can be no greater mistake, as the acid must be made from the best Sicilian brimstone, diluted with distilled water, and especially prepared and tested for electrical use. There is such acid made, and even if it does cost more than the ordinary sulphuric acid, which is doubtful, such outlay is fully justified, as where pence may be spent, tens of pounds may be saved.

What applies to accumulator makers, applies equally to the users of the batteries, and where batteries are bought outright, the quality of the acid ought to be stipulated.

Lightning Research

THE question of lightning causes and effects is under consideration by a committee of the British Association, consisting of Sir Oliver Lodge, Mr. J. Gavey and Mr. Killingsworth Hedges. A paper entitled "The Effects of Lightning," is to be read by the last-named gentleman at the next meeting of the association. This paper will embody about forty reports of the observers of the Lightning Research Committee of lightning strokes by which damage was done to buildings fitted with so-called lightning conductors.

Boston's largest department store, controlled by the interests of which Henry Siegel is president, is to have the largest equipment of electrically-driven escalators in the world. The contract has just been signed with the Otis Elevator Company for the installation of ten of these appliances. There will be two lines of escalators running between the basement and the fifth floor, five up and five down. By means of special mechanism the descending escalators can be reversed and utilized to carry patrons of the store to the upper floors in the extremely busy season.

A change in the motive power in the St. Clair tunnel, which has been contemplated for several years, has been decided upon by the management of the Grand Trunk Railway system and the St. Clair tunnel. Electricity will be used in place of steam locomotion for hauling trains. The third-rail system has been chosen and work is to be immediately started on the installation, which, it is estimated, will cost $400,000.

It has been estimated that there are at the present time in Spain over 1000 works generating electric current for lighting and power, and that in these works over 2000 generating sets are installed. A large proportion of the capital for this enterprise has been obtained from Bilbao. Many of the companies working these electricity undertakings are using water power. In 1903 Bilbao imported 53,336 incandescent electric lamps, and 224,806 in 1902.

It appears that isolated Iceland, cut off from the rest of the world save for slow mails, is to be linked to other countries by means of wireless telegraphic connection with the Shetland Islands or the mainland of the United Kingdom, as may seem best.

THE ELECTRICAL AGE

Volume XXXIII Number 3
$2.50 a year; 25 cents a copy

New York, September, 1904

Entered at the P. O. as 2d-class matter. Copyright, Louis Cassier

ESTABLISHED 1883

Published monthly at 3, 5 and 7 W. 29th Street, New York City.
Telephone No. 1617 and 1618 Madison Square. Private branch exchange connecting all departments. Cable Address—Cassier, New York.

SUBSCRIPTION RATES

The Electrical Age will be sent post free anywhere in the United States and its possessions, Canada and Mexico for $2.50 per year, single copies 25 cents. To Great Britain and all countries embraced in the postal union, $3.75, 15 shillings, 19 francs, 15 marks, or 10 rupees. Send subscriptions to our nearest branch office or agency.

NOTICE TO ADVERTISERS

Insertion of new advertisements or changes of copy cannot be guaranteed for the following issue if received later than the 15th of each month.

LONDON OFFICES

Business Department, 33, Bedford Street. Editorial Department, 22, Henrietta Street. Covent Garden, Strand, W. C.

London Telephone, Post Office, 3807 Central. Private branch exchange. London Cable Address—Revolvable, London.
All remittances to London Office should be crossed London and County Banking Company.

BRANCH OFFICES AND AGENCIES

Subscriptions may be sent to the following branch office or agencies, where they will receive the same careful attention as at the home office in New York:

124, Queen St., Melbourne
359, George St., Sydney
61, Main St., Yokohoma
23, Esplanade Rd., Bombay
33, Loop St., Cape Town
Unter den Linden, 5, Berlin
Nevsky Prospect, St. Petersburg
31, bis rue de Fauburg Montmartre, Paris

General Agents for United States and Canada: The American News Company

Leading Articles

Wireless Telegraphy at the St. Louis Exposition. By a Staff Correspondent........... 161
Electrical Progress in Canada. By George Johnson 169
Electrolysis of Underground Water Mains. By A. A. Knudson.......................... 172
Entries for Electric Transmission Lines. By Alton D. Adams............................ 174
Construction and Insulation of High-Tension Transmission Lines. By M. H. Gerry, Jr. 177
The First Commercial Alternating-Current Railway in America 186
Power-Plant Equipment Notes from the St. Louis Exposition. By D. T. Randall..... 192
Testing Alternating-Current Generators. By B. A. Behrend 199
Developing Electric Current Sales 204
Electric Locomotive Repairs................... 204
Electricity in the Jewelry Trade............... 205
Fires Caused by Electricity.................... 206
Electric Power in British Shipyards. By C. S. Vesey Brown 209
Magnetic Separation. By F. T. Snyder........ 219
Aluminium Electrical Conductors. By R. J. Parke 223
Notes on European Testing Laboratories. By H. Sharp, Ph. D............................ 231

Developing Electric Current Sales

The Denver Gas & Electric Company has long been known in the lighting field as a particularly progressive business organization. One of its recent enterprises in connection with the securing of additional revenue is illustrated by an interesting circular issued by the company's new business department. The circular is in the form of a grayish colored postal card, about 4½ x 7 inches in size, neatly addressed in white ink to customers. On the back appears the following, in well-spaced type:—

"Have you a numbered globe for your porch light? Do you keep it lighted each evening until bedtime? An illuminated numbered porch light with 16-candle-power lamp may be kept lighted 3½ hours for 1 cent, after your fixed charges are paid. To do so would save you much annoyance, be a convenience to your friends when they call, and contribute to the safety of your household. It will make your home more cheerful and bright. Keep your porch light turned on. If anything is lacking, let us know.

"The Denver Gas & Electric Co."

At a cost of little more than a 1-cent stamp for each residence customer, the company thus emphasized the usefulness and inexpensiveness of a simple piece of apparatus that is all too often neglected in modern households. Everyone has experienced the annoyance of trying to read the numbers of houses on strange streets after dark, and it is by careful attention to little every-day details and conveniences of this sort that almost every lighting company can increase its business. It is a good plan to keep in touch with customers beyond the usual routine of bills and receipts, and the instance cited from Denver practice throws light down a path that is worth traveling by many other companies. The more closely electricity becomes identified with the little things of life, the stronger becomes its hold upon the civilized world, and the better becomes the business of supplying current to consumers.

Electric Locomotive Repairs

The adoption of electric locomotives by the New York Central & Hudson River Railroad for its suburban train service opens the way toward the solution of many interesting problems. It is scarcely exaggerating matters to say that, if the opportunity is seized and held from the beginning of operation by the engineering and auditing officials of the company, the most exhaustive and valuable data yet secured in heavy electrical suburban service will be forthcoming. To go a step further, the company will have it in its power to contribute knowledge of the highest value to the engineering world, and it is to be hoped that the financial results of electric operation will be made public, as in the case of the Manhattan Elevated Railway in New York.

It is probable that the cost of repairs upon the electric locomotives will be considerably below the figures which express the maintenance expenses of the best passenger steam locomotives now operating upon the road. This advantage of the electric machines has not been generally noted up to the present time. The steam locomotive is a most useful, rugged and reliable piece of rolling stock, but it is heavier than the equivalent electric machine; complicated by numerous valves, pipes, links and running gears and handicapped by an enormous boiler and heavy tender.

Finally, it is accurately balanced for but one speed, and is subjected to the terrific pounding strains. There is no reasonable doubt that the engineers at present running fast trains by steam power will notice a remarkable smoothness and comfort in operation as soon as they begin to drive the new machine—a condition which is a sure indication of reduced wear and tear. This is mostly to be charged to the uniform torque of the electric locomotives during and throughout every revolution of the driving wheels.

The majority of electric locomotive repairs will probably be cures of minor troubles with the electromagnetic switches, brushes, compressors, brakes and other easily accessible parts. The space taken up in the repair shop will be less than that required by many of the steam machines, and the handling of the various parts by hoists and cranes ought to be an easy matter in

comparison with the care and expense of handling the massive bulks of steam locomotives. Altogether there are many reasons to believe that the maintenance problem will be much simplified by the new machines, and the reduction in such expenses will be worth studying by everyone who has access to the operating figures.

Electricity in the Jewelry Trade

THE electric clock has been slow in coming, but its construction has been so perfected that in the near future it will, to a large extent, banish the old weights and springs for moving the mechanism. The simplicity of the electric clock immediately recommends itself to all, and jewelers and clock manufacturers anticipate better results from this kind of timepiece than from any of the old-fashioned ones. By means of an electro-magnet and a pivoted armature to which a pawl is attached that moves in the ratchet wheel, the ordinary springs and train of wheels are dispensed with. With the swing of the pendulum, the circuit of the electro-magnet and a battery is opened and closed. One good dry-cell battery will operate the clock for months, and when the current is exhausted the cost of renewing is merely nominal. The electric clock thus does away with intricate machinery and the trouble of winding it every few days. The construction is so simple that any one familiar with the elements of electricity can repair it. As the repairs of clocks and watches constitute a good part of the trade of the retail jewelers, the electric clock is not apt to prove so popular among them as the weight and spring clock.

The ease with which any number of these electric clocks may be operated in synchronism is an advantage of no small moment. In factories, mills and large manufacturing plants, where it is essential to have the exact time in all the rooms, the electric clock will prove of peculiar value. By removing the pendulums from all but one clock, with the others connected in circuit, the exact time can be kept with all the clocks in the plant. Furthermore, the regulation of timepieces by electric power from some central station is thus greatly simplified. With a wire running to the main clock of the plant, an exact regulation of all in the series could be instantly obtained.

Electric clocks for watchmen have also been devised so that it is impossible for the operator to change the register, or in any way make the clock show the wrong time when touched. The electric apparatus is carefully locked inside of the case, and when the watchman puts his key in to register the time of his patrol it is impossible for him to manipulate the works in any way to suit his plans. The different clocks operated in synchronism with the watchman's clock also register the hours throughout the night. An attachment has been made which prints on a small tape the hours and minutes when the watchman registered his different beats, and this is conspicuously displayed on the desk of the superintendent when he comes down in the morning. The whole regulation of the timepieces, and the record of the night watchman's work, are thus automatically obtained, and no one, unless they tampered with the wires, could change the registering apparatus.

But the use of electricity in the jewelry trade has been growing in other ways as well. Small electric motors for grinding, drilling, and cutting stones and precious metals have been installed in many of the jewelry shops. Where electricity is supplied from outside sources, the drills and grinding machines that were formerly operated by hand or foot power are now worked by simply running a wire to the lighting apparatus overhead. A very small electric current suffices for this work. The drills and grinding machines are very small affairs, but great speed is essential, and electricity has made the work easier. So delicate is the work that instant regulation of the machine is essential.

Most of the diamond cutting was formerly done in Europe, and nearly all the stones shipped to this country were either set in jewelry or cut for immediate use. A great many are to-day sent here for cutting and polishing, and a considerable trade has grown up in New York in this line. All the work abroad is done by hand, and it was not supposed for years that machinery could be adapted to this labor; but electricity has to some extent solved the problem. The operator has his small cutting instruments revolving before him. By a touch of a button he can reduce or increase the speed, adapting it entirely to the needs of his work. Diamond cutting and polishing is thus done in half the time required when only hand or foot power were used.

The drilling of holes in precious metals frequently requires a good deal of careful and steady work, and jewelers are now simplifying this by using small electrically driven drills. Likewise in polishing precious stones, the small hand lathe has been superseded by the electrically operated machine.

The manufacture of paste diamonds, or imitation diamonds and other artificial precious stones, occupies a good deal of the attention of the jewelry trade. Millions of these imitation stones are used in this country. Their extensive use has developed a line of manufacture that is distinctly new and original. The stones retail for a few dollars apiece, and consequently their manufacture must be on a large scale. A jeweler's shop where they are cut and ground is generally equipped with electrically driven grinders, cutters and drills, so that the work of preparing them for market can be conducted on a large scale. The quartz diamonds are very hard, and demand a very hard cutting point. The quartz is also brittle and easily fractured unless skill and power rightly handled are employed. The electric cutting and drilling machines are considered the best in existence, and it is only through their extensive use that Americans have excelled all others in the variety and quantity of artificial stones.

America now ships them to all parts of the world, and they are so brilliantly cut and polished that only experts can distinguish them from the genuine diamonds. Yet hundreds of thousands of these stones are cut and polished for the trade every year in the New York shops.

Rock crystal is the purest form of quartz, and this is employed extensively in the manufacture of artificial diamonds. As this is difficult to cut and polish, electric machines have been found indispensable by the lapidary.

The cutting and polishing of a huge quartz crystal in the past took as long as a year or two, when the specimen was unusually large and beautiful; but to-day the work could be accomplished within a month or two at the most. The cutting and polishing of agates and onyx by the lapidary have also undergone great changes in the past few years. In making cameos and intaglios from onyx, the small electric cutting tools are superior to any other form of manipulation. Modern chemistry has discovered ways of making many of the artificial stones and minerals so that they can be moulded into form when in a thick fluid state, but, despite this, great demand exists for the genuine articles, cut and polished either by hand or electric machines and tools.

In the past stone cutting could be done abroad for about one-tenth of the price in this country, owing to the very poor wages paid to the operators; but in a modern electrically equipped lapidary's shop the work can be done as cheaply as in Oldenburgh, Bohemia or the Jura without reducing the wages of the operators.

Fires Caused by Electricity

THE extensive use of electricity for lighting and heating would seem to warrant a belief that the general public is familiar with the precautions necessary for its proper use. In the quarterly fire report of the electrical bureau of the National Board of Fire Underwriters, however, the indications are that in many cases the display of intelligence in the handling of electrical apparatus is on a par with that shown in the practice of pouring kerosene into a lighted fire.

The most notable instance cited of this ignorant use of electricity is that in which a defective rheostat ignited a wooden partition to which it was fastened. The rheostat was "home-made," and consisted of coils of iron telephone wire fastened to a wooden frame by staples. Arcing at the contacts ignited the frame, and the fire was communicated to the partition. The person responsible for this construction would probably resent an insinuation that he would be capable of leaving a can of gasolene on a hot fire.

Heat from incandescent lamps has been prolific of destructive fire effects, ten such cases being listed in the report. In one instance the lamp set fire to a paper trimming, and in another, a towel wrapped around the lamp became heated and ignited. The melting of fuses, also, through lack of proper protection, has been productive of seven fires by the falling of the hot metal on inflammable material.

A number of fires are recorded as due to the abrasion of flexible cord in contact with metal pipes. Defective wiring has also been responsible for some fire loss, showing that the wiring contractor is at fault to even a greater extent than the uninitiated, for with the former ignorance will not stand as an excuse.

Several crosses of lines have been reported as causing fires, but these have been few as compared to the other causes just mentioned. A considerable number of fires, however, have been caused by the breaking down of the older types of transformers.

It is the usual thing, nowadays, when the origin of a fire is unknown, to charge it to electricity; but the fire report shows that of 107 fires supposed to be caused by electricity, no evidence could be presented to prove their origin. In addition to these, thirty-nine fires, reported as due to electricity, have, on reliable investigation, been found to be due to other causes.

A will made over the telephone by a St. Louis man was recently filed in the Probate Court in that city.

Brief Topics of the Month

Experiments at the Bank of England have for some time been in progress with a few electric motors for driving printing machines, and so successful have these proved that a complete change is now being made to electric driving for all the printing and other machinery in the bank premises. It is worthy of note, however, that, at last accounts, the telephone was an instrument which had not succeeded in invading the sacred premises.

The postal authorities in Paris are about to put in service a number of electric motor vans for the rapid conveyance of the mails between the post offices and the railway stations. The vans are designed to carry a load of 1200 pounds at a speed of about 12 miles an hour, as compared with the 8 miles attained by the horse-drawn vehicles. The vans are equipped with a battery of forty-four accumulators, one charge of which will enable the vehicles to cover a distance of about twenty-five miles.

The Allan Line steamer "Victorian" was launched at Belfast, Ireland, on August 25. This is the largest turbine vessel thus far built, and is to be ready for service before the end of the year. She is 540 feet long and has a 60-foot beam. The tonnage is about 12,000, and it is expected that 10,000 horse-power will be developed. A wireless telegraph apparatus will be part of the equipment.

During the first three months of 1904 the exports of electrical machinery from Germany amounted in value to $1,309,000, in addition to electric motors valued at $975,000. During the same period the exports of electrical machinery from the United States amounted to $1,561,871, while the total electrical exports, including appliances and telephone apparatus, were valued at $2,642,019.

In the new coal bunker at the New York Navy Yard, each bin is provided with two galvanized iron pipes, 4 inches in diameter and 20 feet long, which are so hung that a thermostat may be moved through the entire depth of coal. Each thermostat is connected with a suitably located annunciator, so that a constant watch can be kept on the temperature of the stored coal.

It is reported from Schenectady that the General Electric Company intends to try the Fessenden wireless telegraph between the Schenectady and Lynn plants. The telegraphic and telephonic communication between these plants is almost constant during the busy hours of the day, from 200 to 300 messages passing between them daily by telegraph, while for telephone service the bills amount to more than $100 a day. Schenectady and Lynn are about 200 miles apart.

According to a recently circulated paragraph in German and French papers it had been contemplated on one of the Swiss railway lines to use electric power by placing electric heaters within the boilers of the locomotives and raise steam through their agency instead of that of coal, the electric current to be supplied by overhead trolley arrangement. The well-known electrical firm, Messrs. Brown, Boveri & Co., of Baden, Switzerland, however, have advised us that there is not any truth in the report and that, as might have been expected, such a plan for electric traction is entirely out of question, even in Switzerland, with its abundance of readily available water power for electric service. "No one," they say, "ever, to our knowledge, seriously made a proposal of this kind."

United States Secretary of Agriculture Wilson announces that as a result of his second trip throughout the forest reserves,plans are in progress looking to the establishment of a space-telegraph system of fire alarms in the various forest reserves under the control of the Government. The idea is to construct an automatic service which will give the alarm when contact is made by the flames or excessive heat. Prof. Willis Moore, chief of the Weather Bureau, will go to the Black Hills reservation to make a thorough examination of the country and report on the proposition.

The American Car Telephone Company announces that it is about to put telephones on the cars of the St. Louis, St. Charles & Western, an electric railroad running between St. Louis, Mo., and St. Charles, about twenty miles, and that a line will be constructed for the purpose of telephoning from stations or offices along the road to persons on the cars. It appears that connection between the car and the roadside is to be made by a separate trolley and trolley wire.

A new line of long-distance telephone, with 292 miles of copper wire, has been opened between Halifax and Sydney, in Nova Scotia. The reports of the company show that in the province of Nova Scotia there is one telephone in use for every 88 inhabitants.

Book News

The Anthracite Coal Communities

By Peter Roberts, Ph.D. Published by the MacMillan Company, New York; 387 pages, 28 illustrations. Price $3.50.

The great strike of 1902 in the anthracite coal regions of Pennsylvania will be long remembered as marking a period of violence, privation and misery. Conflicting statements as to the personalities of the miners were made at that time. Some pictured them as down-trodden victims of capital; others thought of them as ignorant, undeveloped foreigners with hands ready for violence.

Dr. Roberts, however, has tried to show us the miner in his true light and to present the facts relative to his social and moral life. A chapter is devoted to the Slav employees, their homes in their native land, their adaptability as miners, their money-saving ability and their value as citizens. No phase of the miner's life seems to have been left untouched by the author. He takes up the question of marriage, following with statistics of the birth rate and describing the effect of increasing prosperity on this rate.

We are shown the miner in his home, and told of the price paid for his furniture, his clothes, his food and for his amusements. The dwellings themselves are described, and we learn of the condition of the women and the children in these homes.

The author describes, further, the educational features of the mining towns, and the intellectual and religious life of the miner. His ability to save his earnings is told of, and his capacity for mischief as exemplified in the criminal records of the mining district. Neither are his politics neglected, a chapter dealing with this phase of the subject.

In concluding, the author makes a strong plea for the uplifting of the miner through the medium of the school, the church, social influence, and that of the government itself.

The International Fire Prevention Congress at London, England

Report of Prof. Ira H. Woolson, Delegate from the City of New York; 275 pages. Illustrated.

The report of Professor Woolson contains a summary of the work of the congress, together with papers on fire protection in connection with the building, fire and police departments of a city. Some of the papers are given entire, others in extract, accompanied with the discussion in each case.

The conclusions which Professor Woolson has drawn from his observations abroad are that, although the method of building construction prevalent in Europe and the comparative absence of steel construction as practiced in America make the European building laws necessarily different from ours, they are essentially much alike. America is, however, far ahead of Europe in compulsory fire-protection laws. This contrast is especially marked in the cases of New York and London.

The papers read were placed under six sections—building construction and equipment, electrical safeguards and fire alarms, storage of oils and spontaneous combustion, fire survey and fire patrols, fire losses and insurance, and fire tests and standardization. Under the second section the papers were:—Safety and Control Arrangements for Fire Alarms, The Necessity of Automatic Fire Alarm Systems, Electric Wiring and Electric Risks, Electrical Risks in Theatres, and Necessary Practical Safeguards Against Lightning.

Sixteen separate governments were represented at the congress by about 700 delegates, and delegates from a large number of cities and other corporations, fire brigade associations and chambers of commerce were also present.

Electric Motors

By Henry M. Hobart. Published by the MacMillan Company, New York; 458 pages. Illustrated. Price $5.

The theory and construction of direct-current and induction motors are treated from the designer's point of view in the above mentioned volume. In the opening chapter the author discusses the relative merits of alternating and continuous-current motors, and follows with an outline of the main characteristics of the latter type.

The succeeding parts of the book deal principally with questions of design. Types of windings and form-wound armature coils are described with the aid of numerous diagrams. In the examples given of motor design the author has taken types from well-established practice and laid them bare in every part. A chapter is also devoted to comparative designs of a 35-H. P. motor for four different conditions of armature strength and magnetic flux. Variable-speed motors are dealt with, their construction is shown, and the results of tests are plotted in curves. The wiring of the controllers and tabulated data for each position of the controller arms are also given.

The second part of the book treats of alternating-current induction motors. The author discusses the desirability of using polyphase currents in preference to single-phase or two-phase currents. The three-phase induction motor and the methods of starting are described fully, and a comparison is drawn between the induction and the direct-current motor.

The question of design of induction motors is then taken up, this part, with the succeeding chapter of examples of design, forming a very complete work on this subject.

The book concludes with a table of usefully arranged data of the properties of copper wires of the principal gauges in use in different countries.

American Commercial Supremacy in South Africa

According to the "Monthly Summary," issued by the Department of Commerce and Labor, America and Germany have been, and will be, England's greatest competitors for electrical machinery. Considering the fact that many of the largest electrical installations in England have been supplied by Americans or by "English" firms essentially American in everything but name, the British manufacturer may well be a little dubious as to the measure of success likely to be accorded his efforts in South Africa.

Reports from many centers in Great Britain, and, what is more satisfactory, actual inspection, show that British firms are now generally full up with work, and such prosperity is likely to make home manufacturers callous to South African markets. It is here that America scores. The American being up to his chin with contracts seeks to cover his head also. With him success does not cloy; he is keener because of it, and expands and grows to receive it in enhanced measure. Just now, however, the iron, steel and allied trades are far from booming in America, which, on this account, is likely to attack South African markets more vigorously than ever. Her energy and enterprise make America formidable.

In one important respect, however, British manufacturers of electrical and mining plant are handicapped in competition with America. This is due to the fact that the American engineer is very much in evidence in South Africa. In many mines and groups of mines plant and equipment are placed under American control, with obvious and disastrous results to the British manufacturer.

The sympathies of the American en-

gineer are with American manufacturers; his taste for American machinery is as pronounced as his success in installing it in the mines under his charge. Assistant engineers and staff are quickly Americanized, and so far as the machinery and equipment are concerned, particularly where it is electrical, this section of the market is dead to the British manufacturer.

In the early days of mining on the Rand excuse was not wanting for such a procedure, for England could supply neither the men nor the plant. To-day, matters have entirely changed, but the results remain the same; and while British engineers and British mining and electrical plant may be second to none, the American engineer is often given the preference, and under his guidance American machinery is installed. In this matter, hundreds of thousands sterling of plant have been diverted from English into American channels.

Electric Traction at Hong Kong

ACCORDING to "The Electrical Engineer," of London, successful trials have been made of the completed portion of the new electric railway at Hong Kong, China. The initial run was made in the early part of July. Much interest was taken by those present at the trials in the smart behavior of the Chinese motormen and conductors. The general manager said that so far he had every reason to be quite satisfied with the manner in which they had come through the trial. The organization of an efficient staff has been no easy matter. The men were all new to the work, and it has been necessary for the Chinese motormen and conductors to learn the names of all the different parts of the car.

Henceforward, until the opening of the entire system, the Chinese motormen and conductors are to be subjected to rigid training, and there will be trial trips each day. No pains or expenses are being spared to organize a thoroughly efficient and reliable staff in which the public can place confidence.

Niagara Power for Toronto, Canada

ACCORDING to "The Iron Age," a right of way for a power transmission line has been acquired by the Toronto & Niagara Power Company, between Niagara Falls and Toronto, Ontario. The distance between these two points is 86 miles, and when the current of Niagara is transmitted to Toronto, it will be the greatest distance yet covered by a Niagara transmission line.

The width of the right of way acquired is 80 feet, provision not only being made for steel towers that will carry the necessary cables for power transmission purposes, but also for an electric railway which the Toronto & Hamilton Electric Railway Company proposes to build. The announced route of the right of way is from George street, Toronto, to Davenport, and from there in a northwesterly line through Toronto Junction to Lambton Mills, continuing parallel with the tracks of the Canadian Pacific Railway to Islington, and in a direct line to Clarkson, thence parallel with the Grand Trunk tracks to a point north of Bronte, and on in a direct line to Burlington. Here two routes are being considered. One would carry the transmission line across the beach, and another would carry it through Hamilton, but it is not decided which course will be followed.

However, the line will be continued to Stony Creek, and on up the mountain to the top of the escarpment back of Grimsby, from which point the line will run direct to Niagara Falls, Ontario. There will be a branch line $3\frac{1}{2}$ miles long from Islington to New Toronto. Transformer stations are to be built at the head of St. George street and also on Yonge street, Toronto.

The Hull Tramways

THE tramway system at Hull, England, according to the United States consul at that city, is superior in many respects to that existing in almost any American city. It is owned and operated by the city. The cars are double-deckers and the fare is 1d. (2 cents) on all lines and for all distances. The financial results of this low-fare system are equally interesting. During the latest twelve months reported on there were 10 miles of double track, or 20 miles of single track, in operation. The gross income is about $445,000; the cost of operation was about $233,000. This left a gross profit of $212,000, and, deducting interest on the investment and the sinking sum, a net profit of $122,000, or an average of over $12,000 a mile of double track, which went into the city treasury.

In an automobile garage in which the machine tools were driven by belts from a motor, lightning recently disabled the motor and the shop would have been shut down had not a happy thought struck the proprietor. He carried the main pulley belt to the flywheel of the engine of an automobile standing stripped in the garage, and the machines were run while the disabled motor was being repaired.

A Prize for High-Tension Safety Apparatus

ACCORDING to "The Iron Age," American inventors are to have an equal chance with citizens of other countries at a prize of 6000 francs, offered by the Association des Industries de France contre les Accidents du Travail, now organizing to hold a congress in June, 1905, with the object of investigating apparatus which will insure the greater safety of workmen employed on high-tension electric conductors.

The prize will go to the apparatus that will best indicate safely and clearly whether an electric conductor is alive or not. It must be equally applicable to direct and alternating currents of all voltages and must be reliable and incapable of doing damage to itself, the operator or the distribution system under any circumstances. The problem presented to the electrical inventor is a stiff one, and the man who will produce such an apparatus meeting all the prescribed conditions will have earned the 6000 francs. But his success will mean a very great boon to those men whose work brings them into close proximity to high-potential electric wires and machinery.

Now that a current of 60,000 volts has become practicable and is much employed for long-distance transmission, this enormous potential being coupled with large quantities of the electric fluid, the danger to the electrician and to workmen who must be employed in caring for such a line and for the apparatus at its ends has become a very serious matter. Danger through carelessness cannot be remedied by any apparatus, perhaps, but such a device as that proposed by the French congress would give timely warning which would save many lives.

Electric Light Baths

ELECTRIC light baths, according to "Electricity," of London, are quite common in German hospitals. An English physician, Dr. J. S. Hooker, states that he has found them much more effective than drug treatment in rheumatism and like diseases, and as they fill the skin with blood, he suggests that they might be of great importance in bringing out the suppresssed rash of fevers, such as scarlet fever and small-pox.

The use of X-rays in serious blood diseases has given surprising results to Professor Bozzoli, of Turin. He has succeeded in curing a difficult case of leuchæmia, which arises from increase in the white blood corpuscles.

Electric Power in British Shipyards

By C. S. VESEY BROWN

A brief reference to this subject, as reported upon by Mr. Brown, has already appeared in these pages, but a full account of his investigation is now given, together with many illustrations which excellently portray British practice in this particular field.

AMONG the many industries congregated around the districts of the rivers Tyne, Wear and Tees, there are none which have made such rapid strides in the last few years in the application of electric power as that of shipbuilding. It is safe to say that in 1894 there was not an electric motor at work in any of the shipyards in the district for the purpose of driving the tools used in shipbuilding, and possibly beyond a few motors used for cranes, and dynamos for lighting, there was not any electrical apparatus in regular use. In 1904 the situation is entirely reversed, and, with very few exceptions, there is not a single shipyard which does not derive either the whole or a very considerable portion of its power from electricity.

The transition from steam to electricity has been carried out in the face of a period of considerable activity in the trade, practically without any interruption in the work in hand, and advantage was taken of whatever temporary labor troubles there were to complete the transformation, for shipbuilders having once realized the immense advantages which electrical driving presented, were not slow to avail themselves of the opportunity to adopt it. The experience which has been gained by the change from steam to electric driving has shown how very wasteful were the long lines of steam pipes and the many small engines scattered about the shipyards, as for the most part the steam plant consisted of isolated banks of boilers, each with its separate staff and all the paraphernalia of separate coaling and water systems. After the old engines had been all displaced by motors driven from one central station, the economies were found to be almost phenomenal.

It is significant of this experience that at the present time whenever a new tool is required or any alteration has to be made in the arrangement of a yard, there is no question as to what motive power shall be used, but rather how much can the electrical distributing system be improved and how far can any new tool be altered from steam, hydraulic or compressed air to electrical driving. In the majority of cases the original equipment of the plant was carried out with an eye to the future arrangements, but those installations put down in the period from 1894 to 1897 have had, of necessity, to be remodeled in order to keep pace with the electric power progress and to obtain the full benefit of the experi-

FIG. 1.—PUNCH, SHEARS AND ANGLE CUTTER, MADE BY MESSRS. A. & P. MC ONIE, OF GLASGOW, IN THE SHIPYARD OF MESSRS FURNESS, WITHY & CO., LTD., HARTLEPOOL

FIG. 2.—PUNCH AND SHEARS MADE BY MESSRS. A. & W. SMITH & CO., LTD., GLASGOW. DRIVEN BY A BRITISH THOMSON-HOUSTON COMPANY 10-H. P. THREE-PHASE MOTOR AT 400 VOLTS. THE NORTHUMBERLAND SHIPBUILDING COMPANY'S YARD AT WILLINGTON-ON-TYNE.

ence of the past ten years, and such reorganization is taking place at the present time in several well-known yards.

It is difficult to give any comparative figures as to the relative costs of the old steam power and the newer electric installations, owing principally to the fact that as soon as shipbuilders realized the great advantages which electricity gave them to increase their output, they added machines as fast as it was possible to put them down to carry on and extend their business. From figures supplied by a shipbuilding firm who adopted electric driving in its early stages, it is possible to give a comparison of the cost of power per "pound of wages paid" in the years 1894 and 1901, that is to say, before and after the use of electricity. The figures are as follows:—

In 1894 the cost for coal, gas and labor for driving the engines scattered round the yard was 8.66 pence per "pound of wages paid," and in 1901 the cost for coal, labor and other incidentals for producing the power electrically was 4.88 pence per "pound of wages paid," or, in other words, the wages paid in 1901 were practically double those paid in 1894, and the cost for power was the same, and this in spite of a very great increase in the number and size of the machine tools employed, which, in the yard in question, practically amounted in 1901 to six times what were in use in 1894.

The cost of producing a Board of Trade unit varies from slightly under a penny to a penny farthing, depending on the load factor, the area of distribution and the size of the plant. These figures of cost include an allowance of 10 per cent. for interest and depreciation on the generating plant and distributing cables.

The general reduction in the cost of power has enabled the shipbuilder to cope with the increase in the size and the extra fitting out of ships in the present day as compared with what was required, say, ten years ago. In one case, brought to the writer's notice, it appears that the average size of ship turned out by a certain yard in 1894 was 315 feet length by 40 feet beam, while in 1902 the average size had gone up to 475 feet length and 56 feet beam, and the indications are all in favor of this average being considerably increased in the near future.

In addition to the increase in the size of ship, there are other and more onerous conditions which rule in shipbuilding in 1904 as compared with 1894, such as the provision for better passenger accommodation, more efficient cargo-handling equipment, facilities for the carriage of cattle, petroleum, etc., and these requirements have all increased the cost of production in shipbuilding, so that in 1902 the tonnage turned out per man employed in the same yard has fallen to an average of $24\frac{3}{4}$ tons, as against $26\frac{1}{2}$ tons in 1894.

One of the consequences and advantages of the adoption of electric power has been the concentration of all the generating plant into one building, with facilities due to the proximity of the rivers, for condensing the exhaust steam and the supply of a cheaper class of fuel than had been used before in the isolated boiler plants. Naturally the labor bill, too, was greatly reduced. As the result of experience it is found that rarely more than 66 per cent. of the nominal horse-power of motors has to be supplied from the generating plant, so that, in designing any extensions of plant, distributing system or motors, the shipbuilder can with very fair accuracy calculate what will be required in either of these sections of his electrical department.

In the course of the investigations which were made for the purposes of this article, it was found that there was considerable diversity of practice as regards the electrical systems in use. The electrically equipped yards can be roughly divided into three sections, namely, those in which 125-volt continuous current is employed; others where the pressure was either 220 or 250 volts, with continuous current; and the very latest installations, where

three-phase alternating-current at 400 to 440 volts is used.

The first mentioned represent the earlier installations. Examples of these are found at the yards of Messrs. Furness, Withy & Co., and Messrs. Swan & Hunter. As confidence in the use of the power was instilled into the minds of the heads of the shipbuilding industry, and the practice in what was then high voltage, continuous-current became more perfect, later installations were put down to work at 220 or 250 volts, and then, with the advent of the three-phase alternating-current experience from the Continents of Europe and America, this type of installation was adopted as being the very latest and most up-to-date system of distribution. Examples of the 220-volt, continuous-current work are to be seen, among others, at the yards of Messrs. W. T. Doxford & Sons and Messrs R. Stephenson & Co., and of three-phase work at the yards of Messrs. Armstrong, Whitworth & Co., Ltd., Palmer's Shipbuilding and Engineering Company, Ltd., Messrs. Hawthorn, Leslie & Co., Ltd., and the Northumberland Shipbuilding Company, Ltd., all on the river Tyne.

Since the supply of power has been available from the Neptune Bank station of the Newcastle-upon-Tyne Electric Supply Company, Ltd., the use of three-phase alternating-current has been more general, and has so far proved a success, as a considerable number of power users have taken this company's supply at prices which compare favorably with what it would cost the shipbuilder to generate his own supply after making due allowance for interest and depreciation.

There is some advantage in the use of three-phase current over the continuous-current system, especially if a higher pressure than 250 volts be required, in view of the difficulty of lighting the offices from a two-wire, continuous-current system at a higher pressure than 250 volts; but on the score of simplicity there does not appear to be any advantage on one side or the other, and though the question of maintenance naturally arises, as far as could be gathered from works where continuous current has been in use from eight to nine years, the continuous current plant requires only a small amount of attention to the commutators and brushes. The principal repairs in each case are in connection with the starting switches and regulating apparatus, which seem to be the weak points on both the continuous and the alternating-current systems.

In the majority of cases the power plants are owned and operated by the firm who own the shipyard; but, as has already been stated, there are a number of yards along the north side of the Tyne which take power from the Newcastle Electric Supply Company's power station. The yard of Messrs. Swan & Hunter is a notable exception to this, as the power plant in this case was erected in 1895, and is now being remodeled to deal with extensive alterations in the yard and to take advantage of the electric experience gained since that date.

The continuous - current power plants, as a rule, consist of marine-type boilers and high speed steam engines directly coupled to continuous-current, shunt-wound dynamos. One of the older installations—that at the yard of Messrs. Furness, Withy & Co. —shows that there are still a few belt-

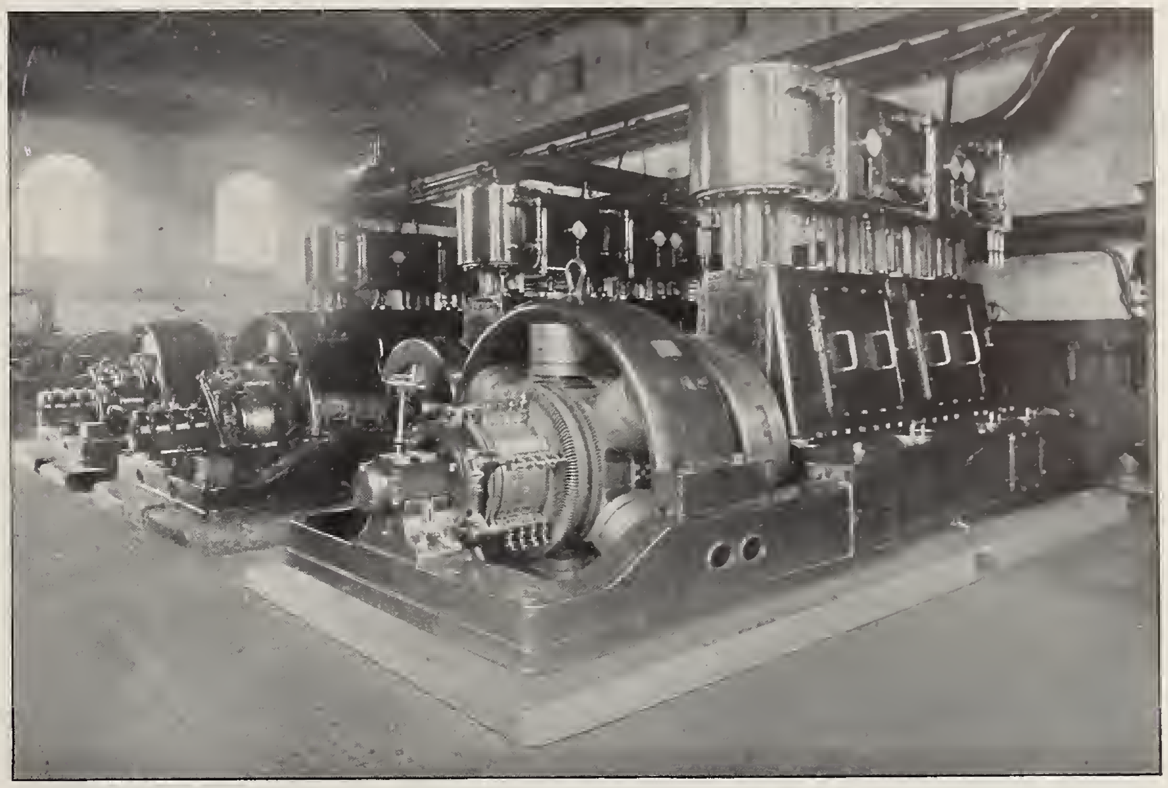


FIG. 3.—GENERATING PLANT AT MESSRS. W. T. DOXFORD & SONS' YARD. ENGINES BUILT BY THE SUNDERLAND FORGE AND ENGINEERING COMPANY, LTD., OF SUNDERLAND, AND DYNAMOS BY THE SAME FIRM, AND ALSO MESSRS. J. P. HALL & CO., LTD., OLDHAM.

FIG. 4.—A VIEW OF THE OVERHEAD EQUIPMENT IN THE YARD OF MESSRS. FURNESS, WITHY & CO., LTD.

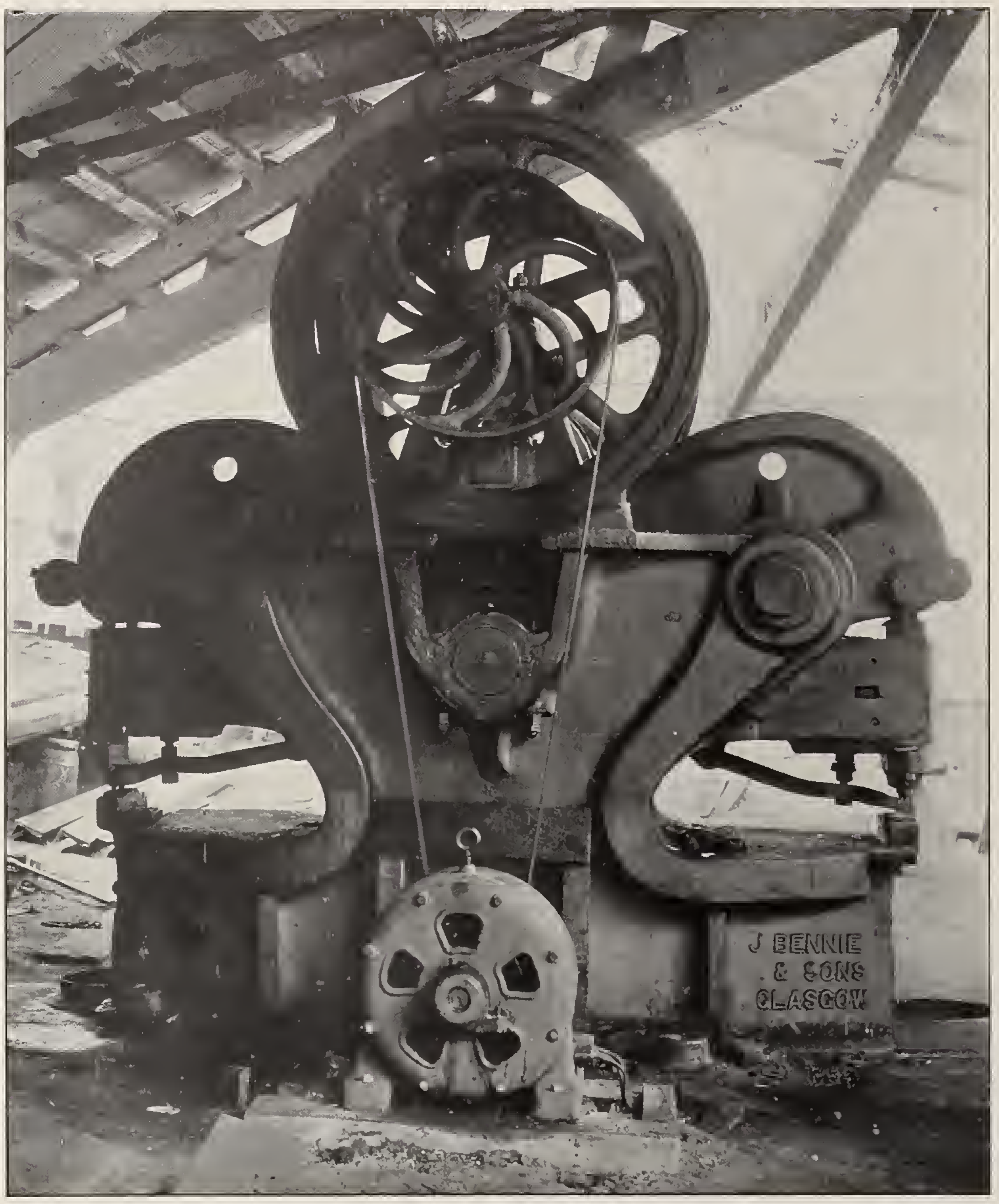


FIG. 5.—A DOUBLE PUNCH DRIVEN BY A BRITISH THOMSON-HOUSTON COMPANY 10-H. P. THREE-PHASE MOTOR

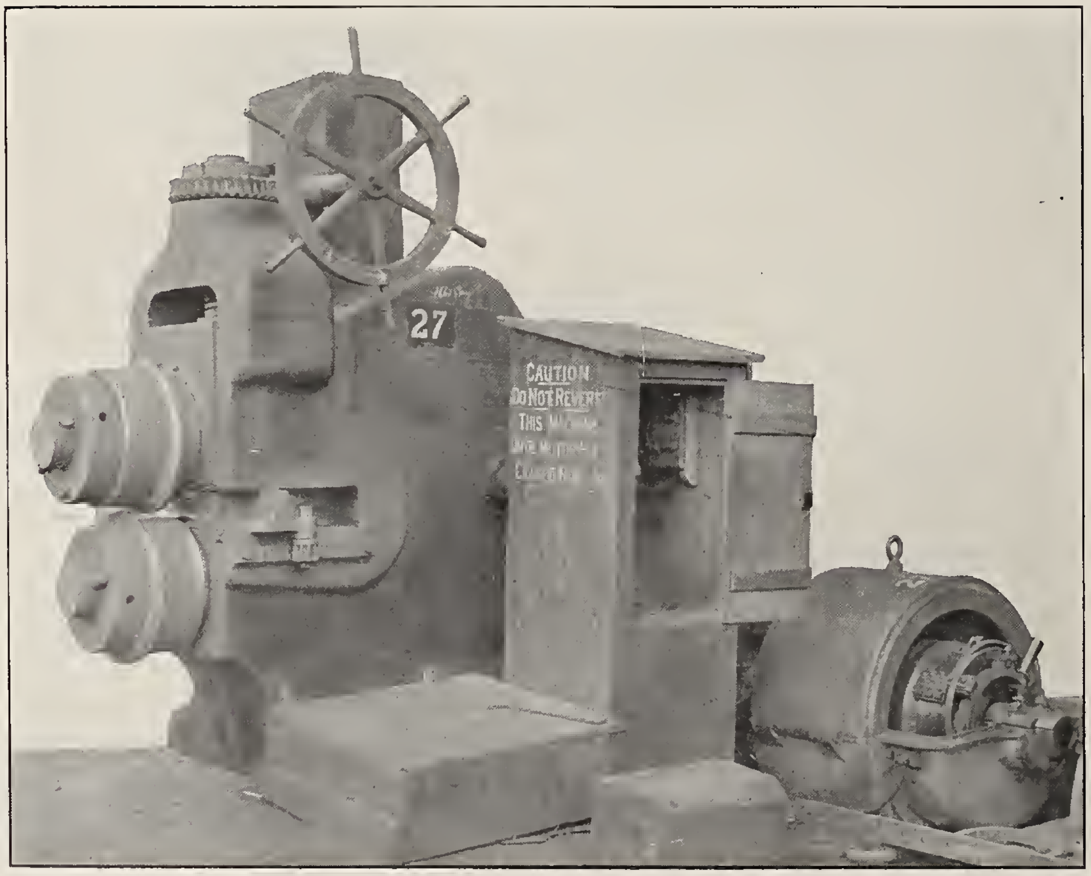


FIG. 6.—DOXFORD'S JOGGING MACHINE, BUILT BY MESSRS. FRANCIS BERRY & SONS, SOWERBY BRIDGE, DRIVEN BY A 25-H. P. CONTINUOUS-CURRENT MOTOR MADE BY THE SUNDERLAND FORGE AND ENGINEERING COMPANY, LTD.

driven plants which have done good service and compare favorably with the more modern high speed steam dynamo.

In using shunt-wound dynamos, no trouble has been experienced with any fluctuations in the pressure of supply sufficient to affect the lighting system, which is always supplied from the same machine furnishing power to the motors. It is natural that lighting should form a considerable portion of the load. Inverted arc lamps are extensively used in the draughting rooms.

Overhead transmission lines are universally used, and consist, for the most part, of rubber-insulated cables attached to porcelain insulators, which are, in turn, fixed to wooden cross-arms on wooden poles. A good example of this work is shown in Fig. 4.

Probably the earliest example of the actual application of electricity to drive shipyard tools in the district was at Messrs. Furness, Withy & Co.'s yard, at Hartlepool, and a short account of this installation will, therefore, not be out of place as showing from what small beginnings the installation of electric power began and what were the remarkable results of a very interesting experiment. Scattered around the building berths in the yard were a number of steam winches used in conjunction with derricks to hoist and hold up the plates, angle-bars and other material required in building ships. These winches took steam from the same boilers that supplied a shop engine of about 70 H. P., used for driving miscellaneous machine tools, and it was common experience that whenever the winches were used, the shop engine could not get enough steam and often was nearly brought to a standstill.

It was suggested to Mr. Withy that, to overcome this defect, he should try the experiment of putting electric motors on the winches and supplying them with power from a dynamo driven by the aforesaid shop engine. This was done. A 50-H. P. dynamo was belted on the same shafting as the machine tools, and motors were fitted to the five winches, with a belt-drive through countershafting on each. The remarkable result of this experiment was that the shop engine supplied the power to the winches and at the same time to the machine tools already coupled to it, and one boiler less was used than formerly.

With such a striking example before them of the effect of electric driving, it is not surprising that the firm decided to extend the use of the power, with the result that to-day all the tools at this yard are run by electric motors supplied from two steam dynamos of

FIG. 7.—A CORNER IN THE YARD OF MESSRS. W. T. DOXFORD & SONS, AT PALLION, SUNDERLAND, SEVERAL ELECTRICALLY DRIVEN TOOLS ARE HERE SHOWN

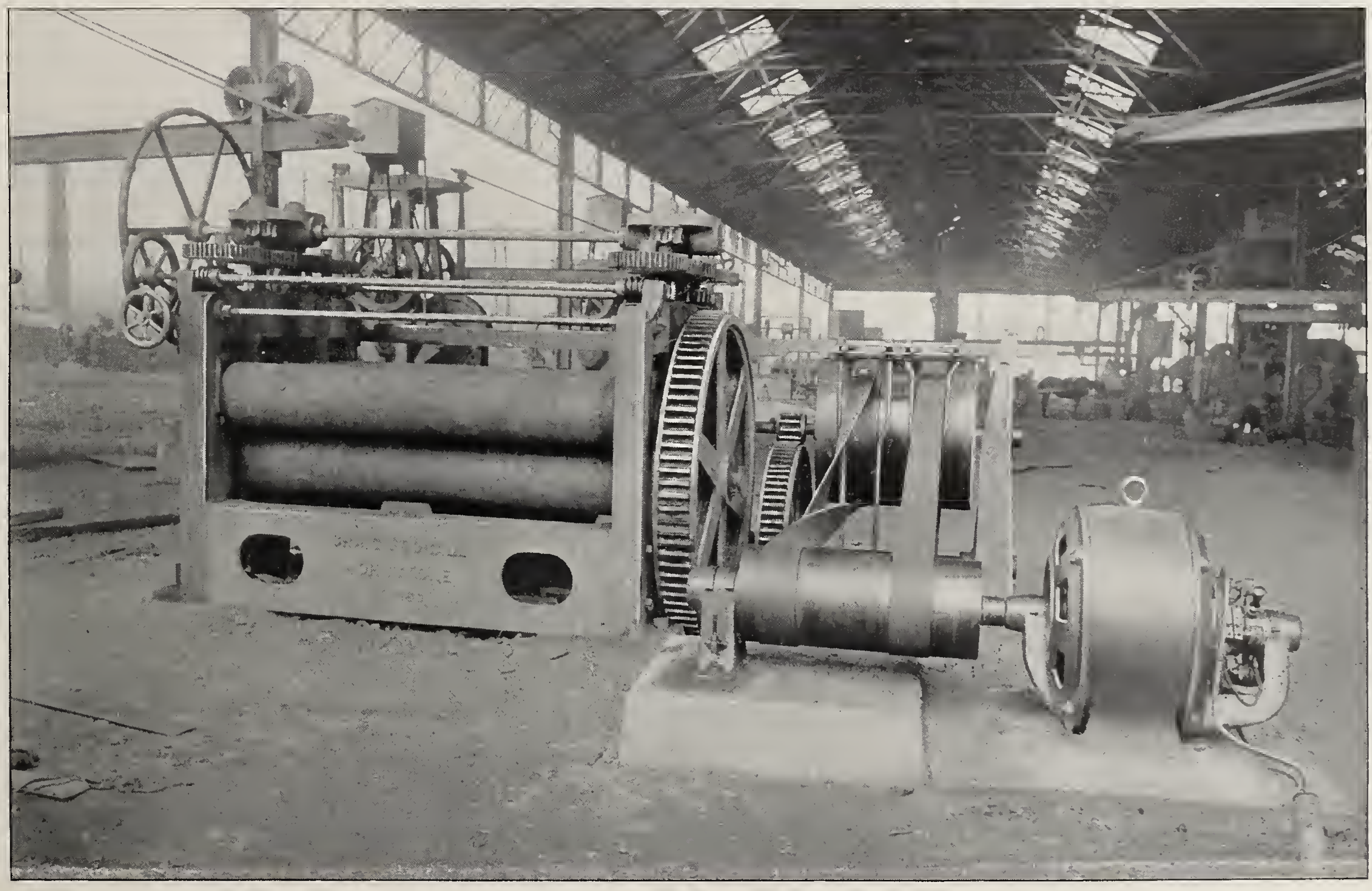


FIG. 8.—PLATE-STRAIGHTENING ROLLS, BUILT BY MESSRS. CRAIG & DONALD, JOHNSTONE, NEAR GLASGOW, SCOTLAND, DRIVEN BY A 13-H. P. CONTINUOUS-CURRENT MOTOR AT 250 VOLTS. INSTALLED IN THE SHIPYARD OF MESSRS. R. STEPHENSON & CO., LTD.

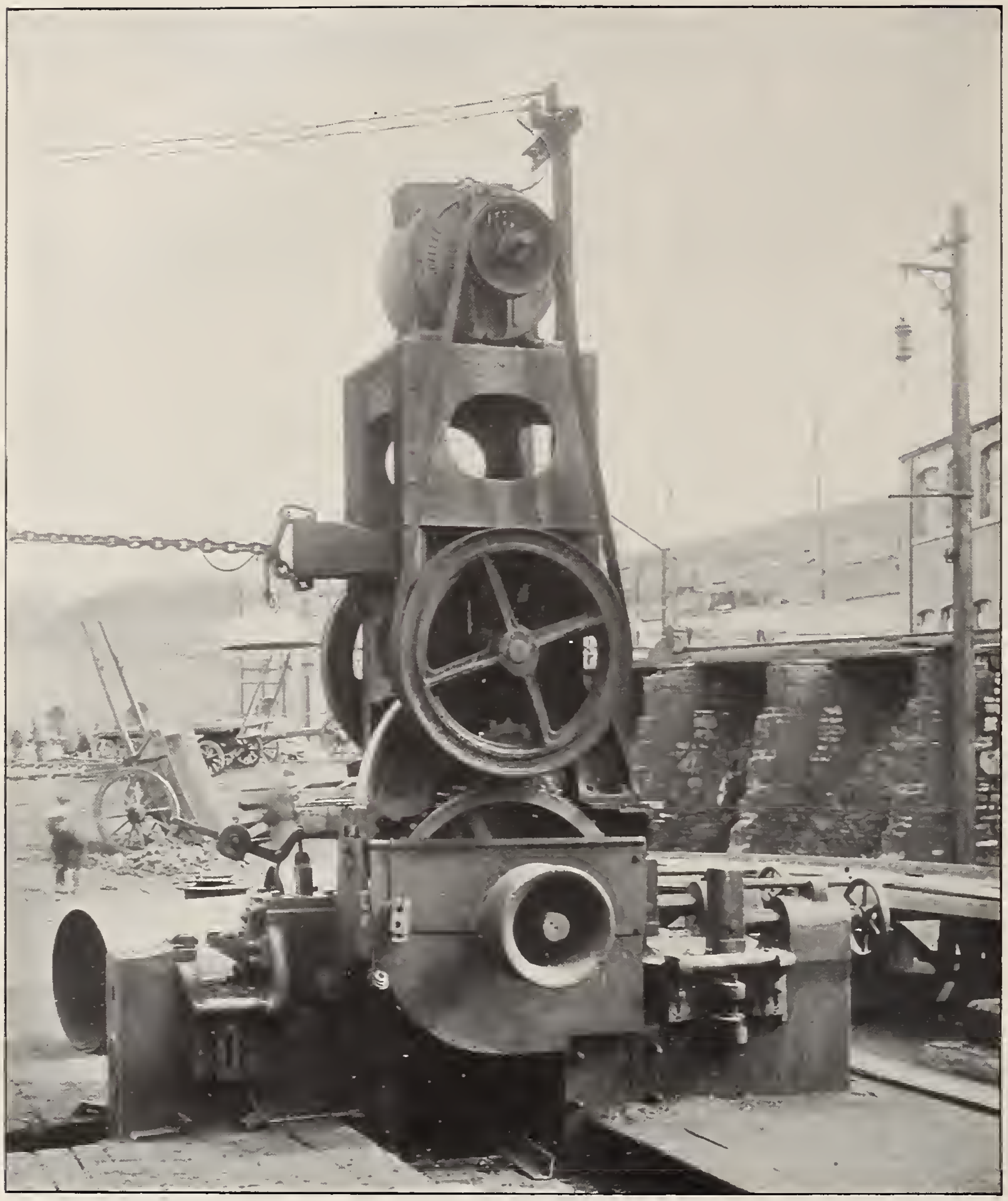


FIG. 9.—HORIZONTAL ANGLE PUNCH, BEAM BENDER AND STRAIGHTENER, AND WINCH, DRIVEN BY A J. P. HALL & CO. 15-H. P. CONTINUOUS-CURRENT MOTOR AT 220 VOLTS, AT THE YARDS OF MESSRS. W. T. DOXFORD & SONS, PALLION, SUNDERLAND

ment for dynamos and motors for the firm's own requirements in the yard. But in time it spread to the supply of wiring for the ships built by the firm and for the small steam dynamos required to light these ships. Each little steam dynamo bears a brass label stating that it has been "tested for 100 hours under full load," a remarkable achievement for a ship-building firm to accomplish in such a comparatively short space of time, and which to a large extent is due to the facilities for manufacturing afforded by the use of electrical power.

Other appliances, such as ash hoists, operated by small electric motors, small bilge pumps, etc., are made by the firm in the same manner and as the result of the facilities above mentioned, and though it is not the intention of this article to describe in detail the manufactures of any one firm, yet the above will serve to show how easily the characteristics of a shipbuilding firm may be altered by the change in the power for driving the machine tools; and when it is stated that, with the exception of the main engines and boilers, the cargo-handling equipment and the steering gear, practically the whole outfit for an ordinary 10 to 11-knot steamer can be turned out from a shipyard which, up to a few years ago, dealt only with the hull, it will be acknowledged that a considerable change has been made for the better in the displacement of steam power by electricity, at any rate from the point of view of Messrs. Furness, Withy & Co.

The usual equipment of tools in a shipyard consists of punches, shears,

300 H. P. each. The plant for supplying the power consists of a marine type Westgarth-English engine driving two Pieper dynamos by belt, and an Anderson Foundry Company's direct-coupled steam dynamo, both engines being supplied with steam from two marine boilers. With the exception of the dock pumps and a large crane, both close to the boiler room, there is not a single steam engine in the yard, and even the hydraulic accumulator pumps are driven electrically.

As previously stated, the increasing requirements for fitting out ships were becoming more onerous, and it was at an opportune time that the application of electric driving enabled the firm to deal with the many problems involved in the extra work in their own yard instead of purchasing from other makers. As an example of what was done it may be mentioned that a department was established for attending to the many motors in the yard, and this very soon became a manufacturing depart-

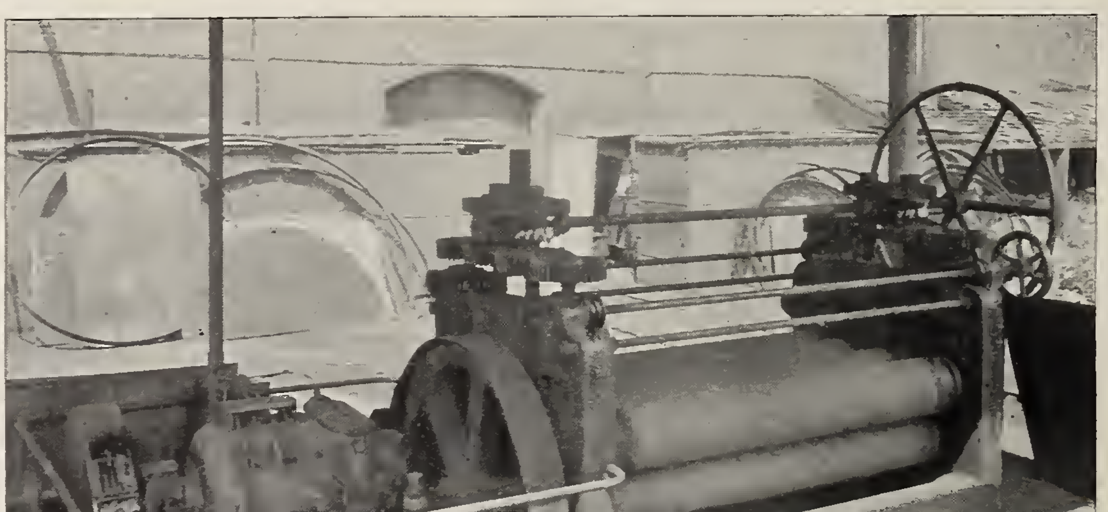


FIG. 10—PLATE-STRAIGHTENING ROLLS, MADE BY MESSRS. CRAIG & DONALD, LTD., JOHNSTONE, DRIVEN BY A BRITISH THOMSON-HOUSTON COMPANY DIRECT-GEARED RAILWAY TYPE MOTOR AT THE WORKS OF THE NORTHEASTERN MARINE ENGINEERING COMPANY, LTD., WALLSEND

plate rolls, winches and other hoisting gear, hydraulic plant, etc. In the majority of cases these tools are identical in design and are treated in the same manner as regards the driving arrangements; but there are a few cases of diversity of practice which it may not be out of place to mention. Punching and shear tools naturally occupy the greater part of a shipyard's equipment, and are made up in all sorts of sizes and combinations to suit certain requirements, such as the provision of angle cutters on the same tool as a punch, and so on. As a general rule, about 10 H. P. are required per machine; but in some of the larger sizes 15 H. P. are necessary.

The machines are generally converted from steam to electricity by substituting for the engine a motor fixed on the top of the tool or on the ground, driving by belt onto a pulley fixed on a straight piece of shaft in place of the old crank-shaft of the engine. Figs. 1, 2, 5, 9 and 13 are all types of punches, shears and angle cutters which have been treated in this manner. Fig. 15 shows a similar tool made for driving through gearing, and gives a very good idea as to the method adopted for fixing the starting and regulating switches. The use of machine tools which have been designed for driving through gearing is becoming more frequent as the tool makers appreciate the advantages of making provision for electric motors on the frame of the tool.

Figs 2 and 5 represent punches and shears driven by three-phase motors with current supplied from the Newcastle-on-Tyne Electric Supply Company's power station. Both illustrations are of tools which have been converted from steam to electricity. Fig. 7 is a very good view of the general manner in which the tools in a shipyard are grouped. In the center is shown one of Messrs. Doxford's patent joggling machines, which were introduced when the firm commenced the turret type of steamer. Fig. 6 shows one of these tools coupled to a continuous current motor made by the Sunderland Forge and Engineering Company, Ltd.

The mangling, rolling and straightening of plates form an important part of shipbuilding, and Figs. 8, 10 and 11 show good examples of different types of tools used for those purposes. Fig. 10 is particularly interesting as showing a novel method of applying the series type of tramway motor, suspended on springs in the same manner as under a tram car.

Fig. 9 shows a type of machine for bending and straightening girders of different sizes up to 18-inch beam. To those not familiar with the numerous and varied combinations which shipyard machine tools are often designed to carry out, it will be seen how much time can be saved by providing at some convenient place a tool, like that shown in Fig. 13, which will straighten girders or angle irons, punch holes in these same irons, and, if necessary, bring them to the machine by means of the winch, all these operations being performed by the same motor.

Other machines illustrated show how the shipbuilder saves much space by combining the different tools in one machine. Fig. 14 shows a machine which is extensively used in all shipyards for giving the necessary bevel to the angle irons in all parts of a ship, and especially where the framework narrows at each end of the ship, so that the plates may lie flat on the surface of the framework. As a rule, the machine is placed on a small travelling bogie and run on a narrow gauge tramway so that it may deal with the heated angle irons from any number of furnaces. The bars are drawn out of the heating furnaces and go straight into the machine, which has the necessary bevel wheels to give the angle iron or girder the required "set," and for which purpose an indicator, which can be seen through the hole in the frame supporting the motor, is provided. The starting and reversing

FIG. 11.—ROLLS FOR HEAVY SHIP PLATES AT THE YARD OF MESSRS. FURNESS, WITHY & CO., AT HARTLEPOOL, DRIVEN BY ONE OF THEIR 40-H. P. CONTINUOUS-CURRENT MOTORS

FIG. 12.—A 30-FOOT PLATE EDGE PLANER IN THE YARD OF MESSRS. R. STEPHENSON & COMPANY, HEPBURN-ON-TYNE, DRIVEN BY A 15-H. P. CONTINUOUS-CURRENT MOTOR AT 250 VOLTS

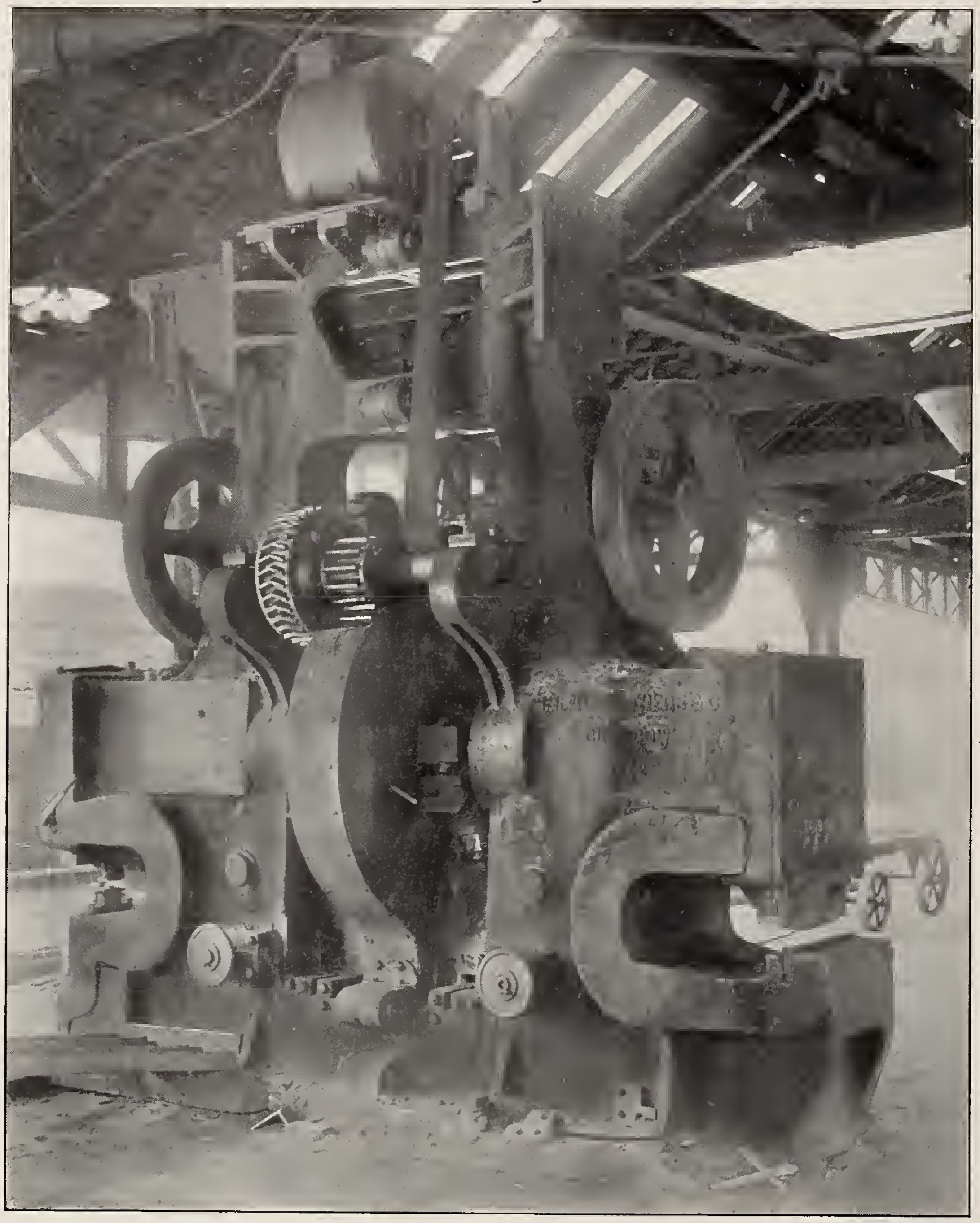


FIG. 13.—PUNCH, SHEARS AND DOUBLE-ANGLE CUTTER MADE BY MESSRS. SMITH BROTHERS, GLASGOW, DRIVEN BY A J. P. HALL & CO. 15-H. P. CONTINUOUS CURRENT MOTOR AT 220 VOLTS AT THE YARD OF MESSRS. W. T. DOXFORD & SONS

controller can be seen at the side of the machine, and the brickwork of the heating furnace can be seen at the left of the machine. The bevelling machine here illustrated was made by Messrs. Davis & Primrose. Fig. 12 shows a 30-foot plate-edge planer, which is in use in all shipyards and is characteristic of similar machines used elsewhere.

One of the important operations in the building of a ship is the handling and hoisting of the heavy plates, angle bars and girders after they have been prepared by the machine tools. Not only must these plates and bars be hoisted into position on the framework of the ship, but they must be held there while they are marked off for cutting or riveting, so that it is most important that quick and easy means should be provided for this work. It is also esssential that the hoisting gear should be capable of being operated without any loss of time or without any particularly skilled attention on the part of the operator, and, further, it is necessary to supply him with efficient brake power and means of releasing the load at the right moment.

A winch and derrick are usually employed for this work. The winch in the old days was operated by steam, but now it is worked by electricity. Figs. 16, 17 and 18 show different types of winches which are operated electrically, and from their general appearance it will be seen that it is not a difficult operation to move one of these tools to any convenient spot to deal with any altered conditions of the work, especially as the size and type of ship vary from time to time.

The winch shown in Fig. 16 is driven by a series-wound motor, and is fitted with a controller similar in appearance and design to a tramway motor controller, so that the operation of hoisting can be carried out at varying speeds and the direction of rotation of the drum reversed if required. The winches are provided with efficient foot brakes which can be used from either side of the winch, and this, in conjunction with the electric brake, allows a good margin of safety in the work.

The winch shown in Fig. 18 is driven by a three-phase, alternating-current motor, and its controller handle is connected to both the controlling and reversing cylinders, so that the operator does not have to think of two operations when working the winch. These winches allow of a speed of from 25 to 50 feet per minute, depending on the weight and size of the warping drum. Fig. 19 shows a pattern of winch supplied for use on board ship, which is also used in shipyards. It is of a heavier design than the other winches illustrated. There are two notable examples on the Tyne of shipyards in which special attention has been paid to the rapid and efficient handling of the material used in shipbuilding. These are the yards of Messrs. Swan & Hunter and Messrs. R. Stephenson & Co., Ltd., and inasmuch as the two yards are practically opposite to each other on the river, the difference of practice is all the more noticeable and interesting. Messrs. Swan & Hunter's arrangement dates back to the commencement of the firm's adoption of electric power, and is coincident with their well-known and unique covered-in building berths which form such a prominent landmark on the north side of the river Tyne.

Fig. 21 is a very good view of one of the berths, and shows the two overhead cranes which run the whole length of the 500 feet which constitute the covered-in portion of the berth. The tracks on which each crane runs are set at the same slope as the ways, namely, 1 in 50, and in order to stop the crane when running at the maximum speed of 300 feet per minute on this gradient an electrical brake operates on the upper shaft by means of a switch conveniently placed to the operator. The tracks are of 12-foot gauge, and are at 22-foot centers from the center of the building. This allows both cranes to deal with material over the entire 68-foot width of the building.

The cranes are each operated by a 25-H. P. shunt-wound motor at 125 volts, which is used as a counterweight to the jib, being mounted on an adjustable frame. The current is collected by insulated contact rings sliding against bare conductors fixed on each side of the track. The power taken by the crane to ascend the track against the gradient of 1 in 50 is about 6 H. P., and as each crane weighs about 14 tons empty, special brackets are provided on the frame so that in

the event of a wheel fracturing, or other accident happening, the crane will drop on the rails about half an inch away. Special precautions are also taken to release the jib, in the event of a plate catching in the framework of the ship or the weight being too heavy, by the release of a trigger as soon as the rope sheave has exceeded its play of 3 inches. The action of tripping this trigger cuts off the current from the motor and at the same time puts the belt on the loose pulley. The regulating resistances allow of any speed for hoisting from 32 feet to 100 feet per minute with loads of from 30 cwt. to 3 tons.

Messrs. Swan & Hunter have also in use a single cantilever crane running on the roof of one of the berths along a track of which one rail is fixed in the gutter and the other on the ridge of the roof of the building. This crane, which was made by the same makers as those inside the building—Messrs. Clarke, Chapman & Co., Ltd.—is worked on practically the same principle as those already described, and is used to handle the material on a third berth which is open to the air and alongside the covered-in berths.

It needs little thought to appreciate how impossible it would have been to work any such arrangement as has been put up at Messrs. Swan & Hunter's yard by other means than electric power, especially from the point of view of economy. To have employed steam would have entailed very much heavier roof work, besides all the difficulties attendant on the conveyance of coal and water to the cranes and the removal of the ashes after the coal was burnt, etc.

The other interesting application of electric power to hoisting gear is the double cantilever crane and gantry which has been put up by the Brown Hoisting Machinery Company at the yard of Messrs. R. Stephenson & Co., Ltd., Hepburn-on-Tyne. Figs. 30, 23 and 24 show the crane and its carriage. The motor is operated by continuous current, is shunt-wound, and is designed to allow the crane to hoist up to 10 tons at a speed of 125 feet per minute for a distance of 50 feet along each arm of the cantilever. The maximum weight which can be lifted at the extreme end of the arm is 3 tons, and as the effective reach of these arms is 89 feet, it will be seen that there will be no difficulty in handling material for the largest ships now being built.

The crane is so designed that it will carry the heaviest load at a speed of 350 feet per minute against a wind pressure corresponding to 30 miles an hour, and as the speed across the cantilever arm is from 400 to 800 feet per minute according to the load, little time is lost in transferring the hoisting carriage from one side of the gantry to the other. In this manner there is no difficulty in dealing with the building of two ships at once, as was intended when the crane was put up. The same type of crane has been erected at the yard of Messrs. Vickers, Sons & Maxim, Ltd., at Barrow. As the crane is operated by one man and takes very little more power than the cranes already described, there appears to be considerable advantage in this method of handling the material for two ships as against that in vogue at Messrs. Swan & Hunter's yard; but, on the other hand, if there is much holding-up to be done, then the four-crane arrangement has the advantage.

As hydraulic work forms a considerable part of the art of shipbuilding, it is necessary to provide an extensive pumping installation in a shipyard to supply the numerous hydraulic riveters, flanging and punching machines, etc. For this purpose either direct acting or three-throw pumps are employed. Fig. 28 shows how the latter type of pump is operated electrically at the yard of Messrs. Furness, Withy & Co. It will be seen from the illustration that the striking gear which operates the motor starting and stopping switches is placed so that as the accumulator ascends to its full height, or lowers as it is emptied, it operates a small piston supplied from the accumulator, which, as soon as the motor is started and is up to speed, throws the belt on the pumps on to the fast pulley and throws the full load—in this case 40 H. P.—on to the motor, reversing the operation when the accumulator is full.

As this cycle of operations takes

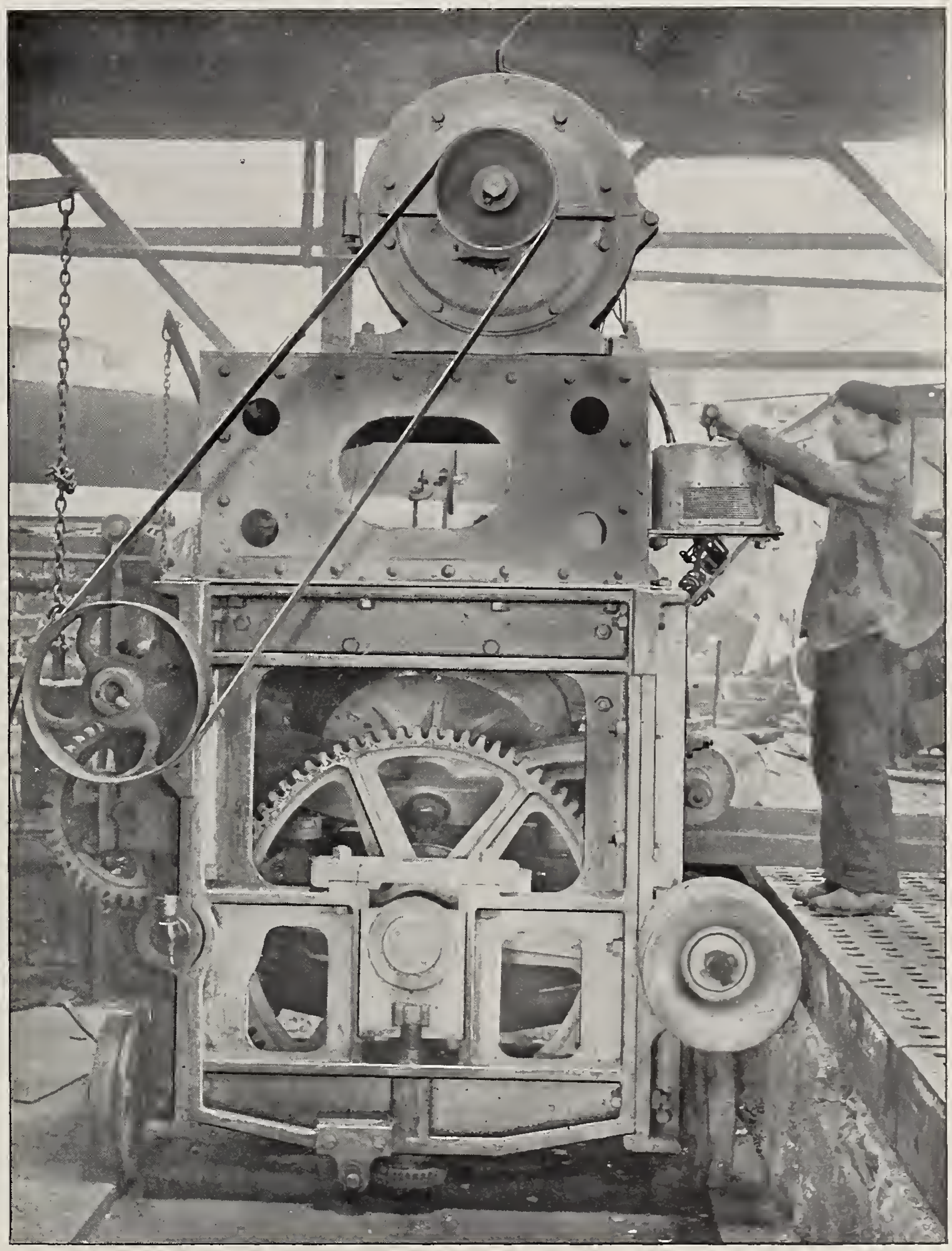


FIG. 14.—ANGLE BAR BEVELING MACHINE, MADE BY MESSRS. DAVIS & PRIMROSE, EDINBURGH, AT THE YARD OF MESSRS. J. L. THOMPSON & SONS, SUNDERLAND, DRIVEN BY A 10-H. P. CONTINUOUS-CURRENT MOTOR AT 220 VOLTS, MADE BY THE SUNDERLAND FORGE AND ENGINEERING COMPANY, LTD., PALLION, SUNDERLAND

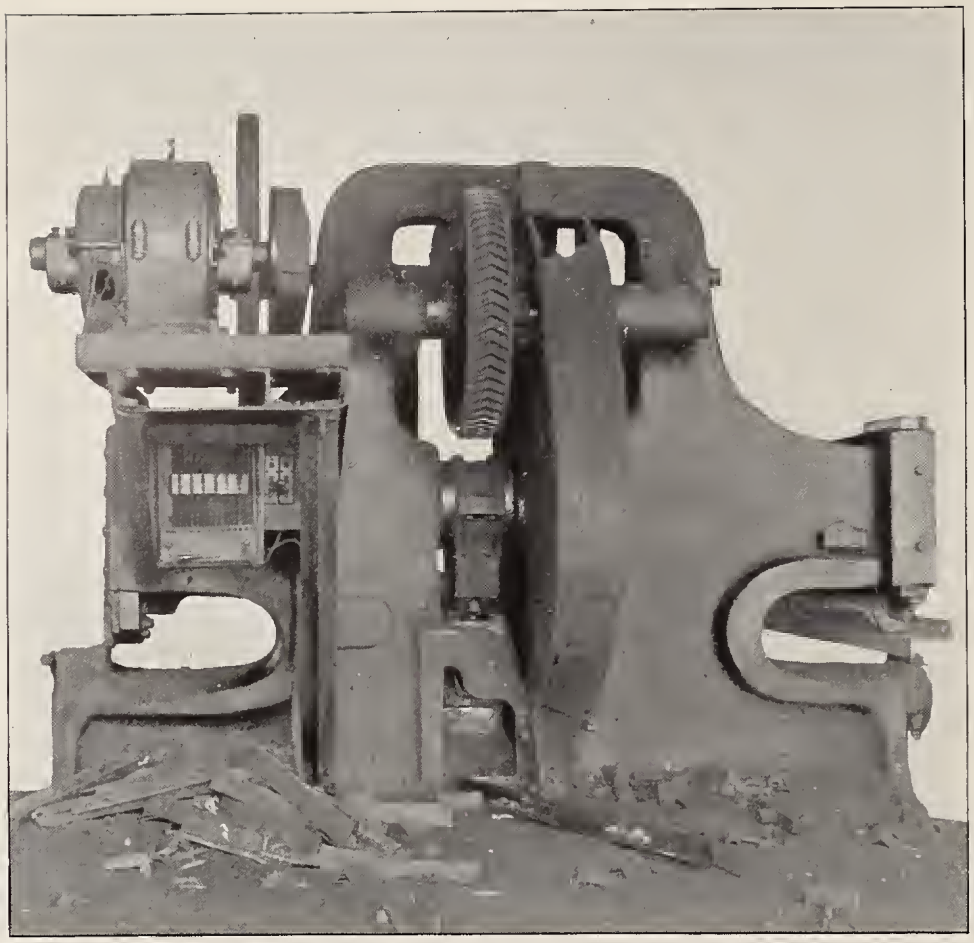


FIG. 15.—PUNCH, SHEARS AND ANGLE CUTTER AT THE YARDS OF MESSRS J. L. THOMPSON & SONS, NORTH SANDS, SUNDERLAND, DRIVEN BY A 10-H. P. CONTINUOUS-CURRENT MOTOR, MADE BY THE SUNDERLAND FORGE AND ENGINEERING COMPANY, LTD.

place many times in the course of a day's work and at varying intervals, there is a considerable strain on the motor, which has to run practically without attendance beyond occasional oiling up. From the appearance of the commutator and brushes of the motor shown in the illustration after about five years' work, it would appear that Messrs. Furness, Withy & Co. have solved the problem of building a sparkless shunt-wound motor.

While on the subject of riveting, which is done entirely by hydraulic riveters, or, in inaccessible places, by hand, it is worth noting that no attempt has apparently been made to introduce electric riveters into shipyard practice in Great Britain, though there are numerous examples in engineering works on the continent of Europe. There ought not to be much difficulty in operating a small series-wound motor for this purpose, and for repair work or in places inaccessible to the heavy hydraulic machine a small electric riveter would be of considerable service.

After the ship has been built and launched, there is a considerable amount of woodwork to be done. Fig. 20 shows a portable electric saw bench, such as is used when laying ceilings, for example. The saw is mounted on a trolley, to enable it to be wheeled to any part of the ship, and the provision of a turntable on the frame allows the top part of the machine to be turned to any desired angle without altering the base, so that short or long special pieces of timber can be dealt with in confined places. The machine is compact and handy. A difficulty which confronted the shipbuilder when he started to equip his yard with electric motors was that of dealing with the supply of steam to his steam hammers, and until the atmospheric power hammer shown in Fig. 29 was brought out, there still remained the losses due to long steam pipes to steam hammers. The principal operation of the hammers is the drawing-out of wedges, and as the hammer illustrated can give about 165 blows a minute, or about the same as a steam hammer, the difficulty is removed. The hammers take from 12 to 20 H. P. to drive them.

Other applications of electricity in shipyard practice include the use of electro-deposition plants for galvanizing stanchions, rails and other exposed iron work which is likely to be rusted. This work is, as a rule, carried out by low-tension dynamos, run at a very low voltage and large current capacity. The repair of faulty castings is also a feature of the equipment of some yards, and by the aid of a low-tension dynamo and carbon pencils it is possible to fill up holes and flaws in such castings.

Though not connected with shipbuilding, the possession of a dry dock is very often an adjunct to a shipbuilding yard, and it is not out of place to mention one or two examples of this class of work. At Palmer's works, at Jarrow, the dry dock is pumped out by two centrifugal pumps, each driven by a 50-H. P. Westinghouse three-phase motor, supplied with current from the company's own power station. This installation, which is the largest privately owned power plant in the district among ship yards, supplies both the shipyard and engineering shops of the firm, and consists of two 1000-H. P. triple expansion marine engines di-

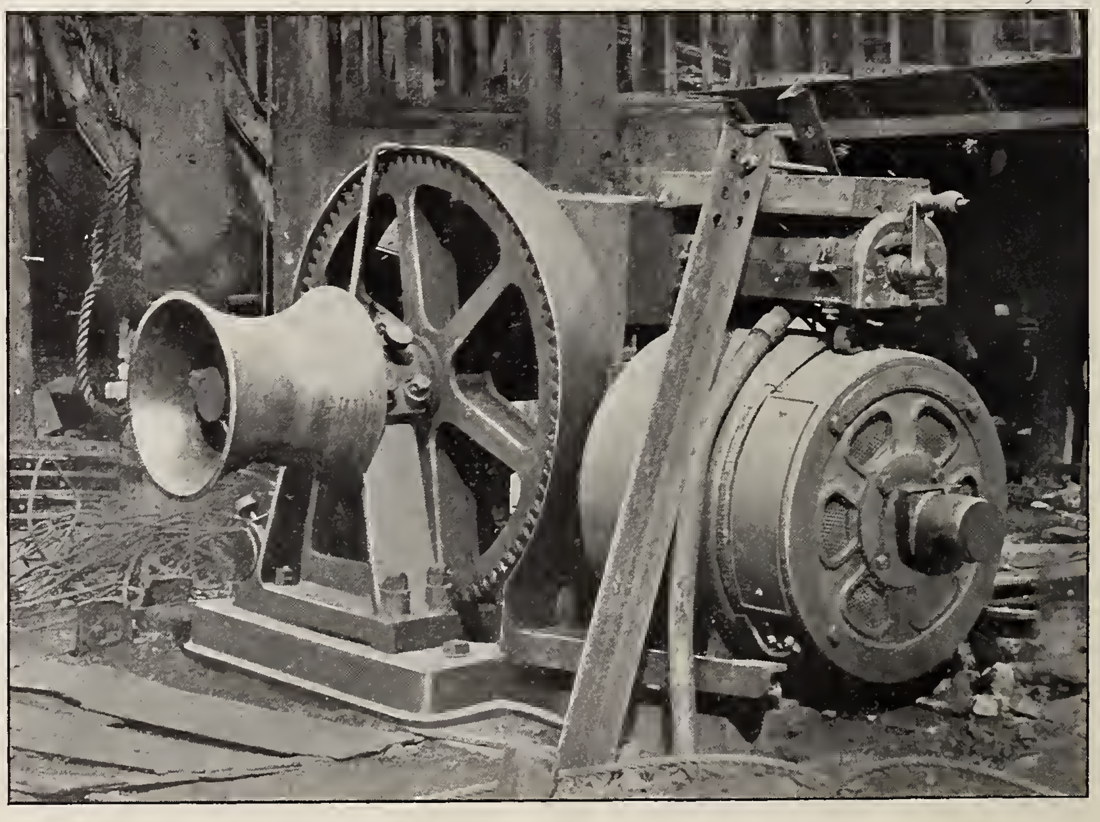


FIG. 16.—AN ELECTRIC WINCH MADE BY THE SUNDERLAND FORGE AND ENGINEERING COMPANY, LTD., OF SUNDERLAND

rectly coupled to Westinghouse three-phase generators which furnish current at 440 volts. The generators are of the usual standard Westinghouse rotating field type, and are shown in Fig. 22.

The motors perform much the same class of work as has already been described. The only feature calling for special mention is the arrangement for starting up the large motors "on load." In this case the current is first of all transformed down on each motor to a lower pressure, so that the 400-volt mains are not suddenly called upon to supply a large current, and as soon as the motor is up to speed the transformer is cut out and the motor is transferred to the mains direct at 400 volts. In this manner a considerable reduction is effected in the fluctuation on the supply mains.

Another example of dry-dock pumping is that of a plant which has been installed by Messrs. Scott & Mountain, Ltd., at the Blyth Shipbuilding Company's docks, at Blyth. The motors are shown in Figs. 25 and 26, and are each capable of developing 140 H. P. when supplied with continuous current at 500 volts. The power in this instance is supplied from the power station of the Northern Counties Electricity Supply Company, Ltd., at Blyth. The use of the electrically-driven pumps has demonstrated very clearly that a considerable economy in both the cost of pumping and the time taken to pump out the docks has been effected.

In a descriptive article of this character there is a great deal of matter which is present day common knowledge, and many articles and papers have been written showing the advantages of electricity over other methods of power distribution; but the aim of this comparatively short and cursory review of the developments on the northeast coast has been to show how very largely the application of electric power has entered into the operations of the shipbuilder, and how, in a comparatively short space of time, a complete change has been brought about, not only in the manufacturing methods of the shipbuilder, but in the characteristics of his business. There is no doubt that by the aid of electric power he has been able to deal with problems in the construction of ships which would have been more difficult to solve than if the agency of electricity had not been near at hand to help, and it would be difficult to gauge how much the rapid adoption of electric power on the northeast coast has been responsible for the period of industrial activity which has been in evidence in the district during the past eight or nine years.

Magnetic Separation

By F. T. SNYDER

From a Paper Read before the Canadian Mining Institute

EVERYONE is familiar with the simple fact that a magnet will pick up small pieces of iron; many persons are familiar with the fact that sufficiently powerful magnets will attract a large number of materials in which the presence of iron is, at least, not in evidence, but few persons realize that the design of magnetic separators and the practice of magnetic separation have developed to a point where it can be stated that there is no material which cannot be moved by magnetism if the commercial conditions under which its movement is desired will permit of the necessary expenditure. For many materials this cost is usually prohibitive, but, as a curiosity, pieces of wood, apples and other things generally considered magnetically inert, have been moved through distances of several inches.

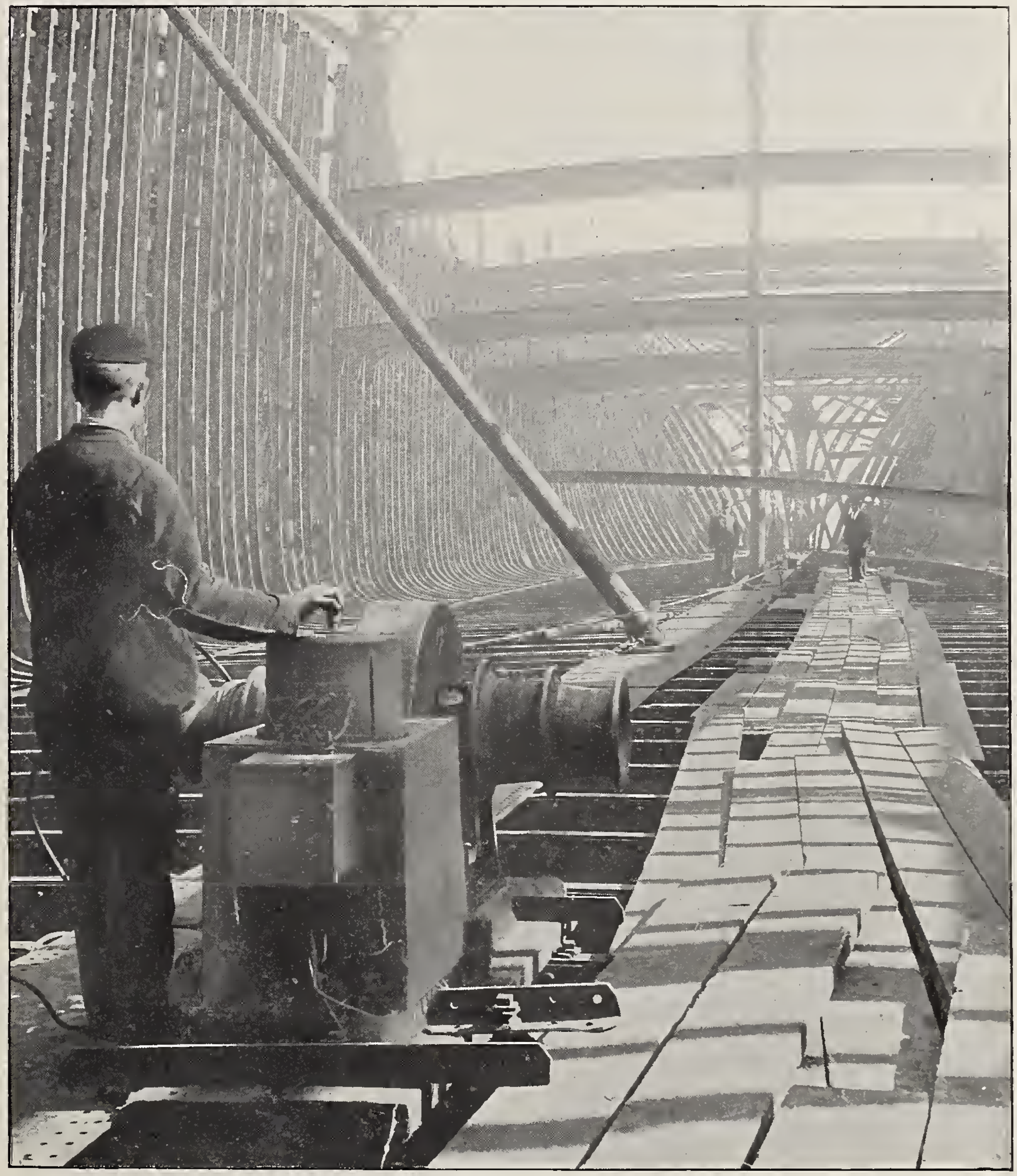


FIG. 17.—A SERVICE VIEW OF THE WINCH SHOWN IN FIG. 16. SEE PAGE 218

In the early days of magnetic attraction, previous to half a century ago, it was generally thought that the law of magnetic attraction was simple, and even quite recently it has been stated in text books that the attraction of a magnet for a movable particle varied directly as the strength of the magnet and inversely as the square of the distance. This, in common with the other simple laws of natural phenomena, has proved to be simple only under theoretical conditions which are not secured in practice. However, the law of movement of a free particle in a magnetic field was understood and perfectly formulated at least half a century ago. In such formula the distribution of the field is assumed as

known, while it is from this factor that the complications in the theory of magnetic attraction usually occur.

The early types of magnetic separators consisted of a straight-bar permanent magnet, or an equally simple electro-magnet. The material to be separated was either touched by one end of this bar or allowed to fall near it and in that way dragged out from the non-magnetic material. From this were developed numerous types of machines, similar in theory but better in mechanical form. Two troubles which developed were, first, the entanglement of non-magnetic material by the material attracted, and second, the question of getting the attracted material off the magnet again so that the magnet could operate continuously. Most of these machines were weak and applied to highly magnetic materials only and as the results were indifferent, the commercial growth of the industry was slow.

During this time—that is, in the period of the last twenty years—the question of magnetism has come to be relatively very well understood in connection with the design of dynamo machinery, and as the necessity for magnetic concentration was urged with more and more persistency, it eventually fell into the hands of competent dynamo designers. The result was magnetic separators of greatly increased power, and from them has developed a knowledge of the design of such separators, which makes it possible to-day to build a separator which will handle practically all materials, the limit being that the more difficult the material is to handle the greater will be the cost of the machine, and consequently the less return commercially.

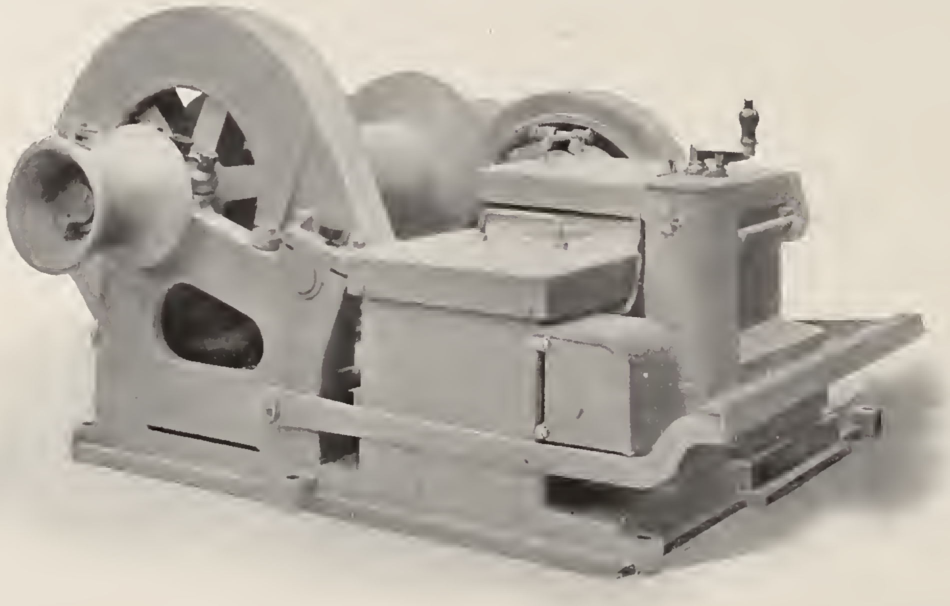


FIG. 18.—A WINCH DRIVEN BY A BRITISH THOMSON-HOUSTON COMPANY THREE-PHASE MOTOR AT SIR W. G. ARMSTRONG, WHITWORTH & COMPANY'S YARD AT WALKER-ON-TYNE

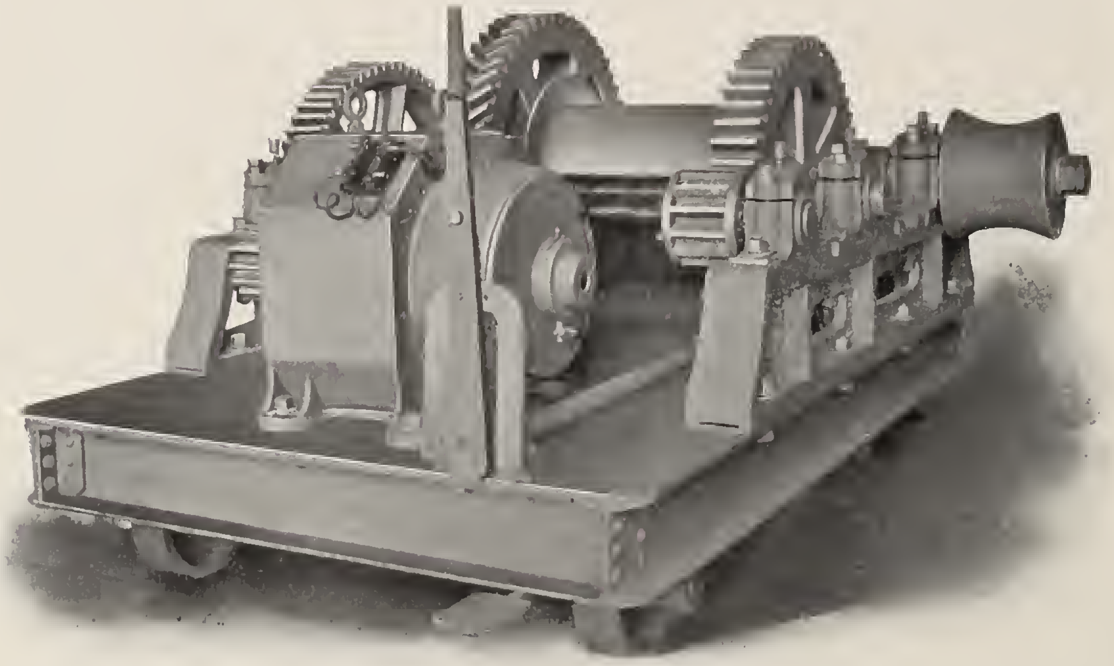


FIG. 19.—A SHIP WINCH DRIVEN BY A CONTINUOUS-CURRENT MOTOR SUPPLIED BY MESSRS. BRUCE PEEBLES & CO., LTD., EDINBURGH. SEE PAGE 216

This great advance in design was largely due to the conception of a magnetic field as made up of lines of force which are assumed to emerge from a pole piece of one polarity and pass through the air to a pole piece of opposite polarity. In the production of this magnetic field the conditions are similar to those in an electric circuit, the magnetism produced being the equivalent of the current.

The magneto-motive force due, in electro-magnets, to the current circulating in the windings of the coil, is the equivalent of the electro-motive force in the electric circuit, while the resistance of the magnetic circuit is analogous to the resistance of the electric circuit. It was early seen that a large portion of the cost of exciting a magnet was due to the resistance of the parts of the magnetic circuit at which the lines of force were compelled to jump through the air, air having a very high magnetic resistance as compared with iron. In an endeavor to reduce this resistance, the air path was shortened by bringing the magnet poles close together.

In the early types of machines the material to be separated was passed through the field in such a manner that both of the poles were on the same side of the material, so that in falling the material passed through the loops of the lines of force twice. It was this looping of the lines that led to the entanglement of the non-magnetic materials with the magnetic materials, and it was this entanglement that eventually led to the abandonment of this looped field type of machine for the type where the material to be separated passes between the poles and through the magnetic field but once, and, in consequence, escapes entanglement.

The freeing of material which had been attracted was at first secured by means of scrapers, and later by reducing the field at the point where the material was desired to be freed; but it is now generally obtained in the best machines by reversing the magnetism, producing a neutral point at which all material of whatever attractability is dropped. So well have the principles of the design of a magnetic separator come to be understood that a difference of magnetic susceptibility now offers in many cases a way of concentrating minerals other than the customary way of taking advantage of the difference in specific gravity.

From its highly attractable property and from its low value, which prevented ordinarily any other method of concentration, iron ore has naturally been a special field for magnetic separation. This has been with two specific ends in view—one the enrichment

of a low grade iron ore for the purpose of reducing the freight to a furnace, and also the furnace cost of operation per unit of iron smelted. The other use has been to free the iron from deleterious materials, such as titanium, phosphorous and sulphur. Where these occur in separate crystals which can be liberated by crushing the iron ore, the resulting separation is one which frequently proves commercially feasible. In the case of sulphur, the success depends on the fact that the sulphur compounds usually found in iron are either more or less magnetic than the iron oxides of the ores.

The separation of iron has divided practically into the separation of magnetites—that is, iron oxide, which is naturally magnetic and can be picked up with an ordinary hand magnet—and the hematites and limonites which are less magnetic, usually so feebly magnetic as not to be attracted by a hand magnet.

In the enrichment of hematites the question has divided into two different sorts of separation—one, the separation of high grade hematites from a sandstone in which they occur as a conglomerate, having been deposited as detrital material from older iron beds along with the sand; the other, the separation of siliceous material which was originally deposited at the same time as the iron and usually in the form of intimately entwined crystals.

The question of the physical condition of iron ore with reference to its impurities is one of the more important in the magnetic concentration of such material. One of the first of the questions which are asked by a furnace man when approached on the subject of iron concentrates is "the amount of fines." If it is necessary to crush the material to such fine size that most of it will blow out of the top when put into a furnace, the purchase of any considerable tonnage of such material is evidently a matter to be approached with caution. Briquetting has made material advances, and large experiments are being carried on at present in the smelting of briquetted iron material. It should be noted that this matter of briquetting and the production of fines is entirely a question of the physical character of the ore. Magnetic separators now handle such feebly magnetic materials as hematite in chunks of practically any desired size, separators being constructed to concentrate material up to 1 inch in diameter.

The cost of building and operating a separator increases about in proportion to the size of material which it has to handle. It is therefore a commercial matter as to whether the cost of briquetting or the cost of concentrating at a larger size, outweigh one another. Almost invariably it is cheaper to build a machine capable of handling larger sizes than it is to briquette as, in general, briquetting costs more per ton than the cost of separation, including interest, depreciation and royalties on the separator when handling material as large as 1 inch in diameter.

The need of briquetting iron ore for use in a smelting furnace is brought about by the high pressure of the modern blast. If this blast could be eliminated, within certain limits it would be a matter of indifference as to whether the material was coarse or fine. It would still have to be granular enough to permit the escape of the gases generated in the smelting operation. Electric smelting provides the required condition that there need be no blast. The magnetites, being iron oxides, need only be mixed with carbon in the shape of any clean fuel, such as coke or charcoal, and subjected to the heat generated by an electric current, to have the carbon join with the oxygen of the magnetite and escape as carbon monoxide, leaving the iron to be tapped off in the form of pig. The St. Lawrence magnetites could probably be dredged up and concentrated wet into an iron ore of high grade and delivered in the Ottawa Valley for a cost not to exceed $1 per ton. Their commercial utilization by means of magnetic separation would appear to offer the promise of a very considerable industry when taken in connection with smelting by means of the water power of the Dominion.

Of next importance commercially, from the standpoint of magnetic separation, is the separation of the mixed sulphides of lead, zinc and iron. This so-called "Leadville problem" has existed for many years. There was in this camp a large tonnage of zinc-lead ore which was too high in zinc to permit the lead furnace man treating it without getting into serious difficulty through the choking up of his stack from zinc accretions, and too high in lead and iron to prevent the zinc smelter from treating it without the destruction of his retorts through slagging by lead and iron. The specific gravity of the zinc and iron was too close to permit of commercial water separation. Through zinc interests which were looking for an additional supply

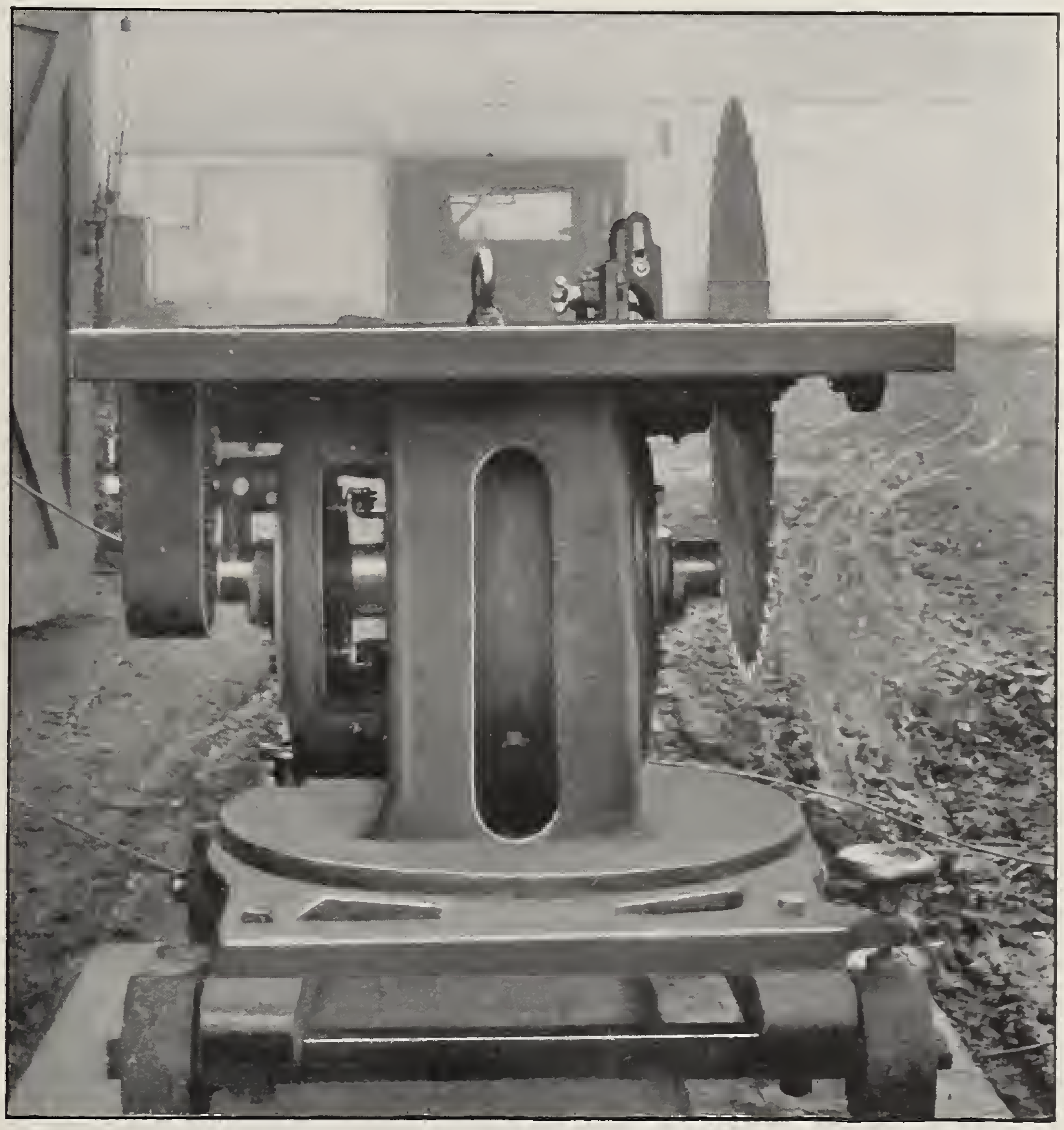


FIG. 20.—A PORTABLE CIRCULAR SAW IN THE YARD OF MESSRS. J. L. THOMPSON & SONS, LTD., SUNDERLAND, DRIVEN BY A CONTINUOUS-CURRENT MOTOR SUPPLIED BY THE SUNDERLAND FORGE AND ENGINEERING COMPANY, LTD. SEE PAGE 218

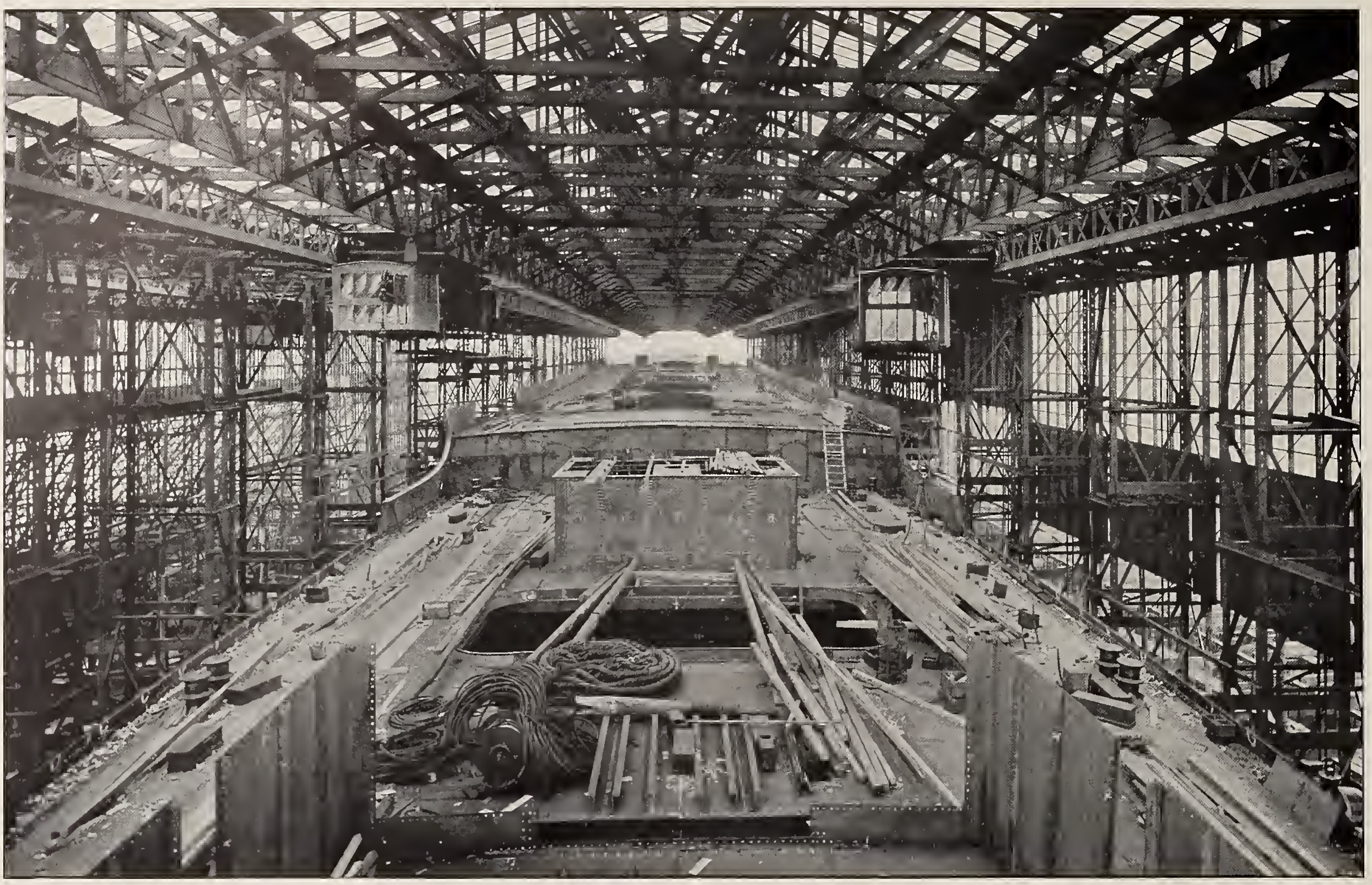


FIG. 21.—ELECTRIC CRANES IN ONE OF THE COVERED BERTHS OF MESSRS. SWAN & HUNTER, AT WALLSEND. THESE CRANES WERE MADE BY MESSRS. CLARKE, CHAPMAN & CO., LTD., OF GATESHEAD. SEE PAGE 216

of zinc ore, this problem was attacked along the lines of magnetic separation, and in its solution was secured much of the data which now forms the basis for an established magnetic separation industry.

A parallel problem existed at Broken Hill, in New South Wales, Australia. Here the lead and zinc were so intimately mixed that, when crushed to the proper mesh for separation, a large amount of the lead was lost by sliming, and the zinc concentrates which were secured were too low in grade to stand the freights to a European smelting point. Here, as at Leadville, the introduction of magnetic separation has resulted in the utilization of a very large tonnage of what was heretofore waste material.

In British Columbia there exists a similar problem. It might be pointed out that there existed two different ways of handling this problem. The mixture of zinc and iron sulphides may be roasted to reduce the iron sulphide, which nominally is almost entirely non-magnetic, to a form of a highly magnetic sulphide, or it may be roasted further to bring the iron to the condition of a magnetic iron oxide, in either of which conditions it may be removed as the magnetic product.

Operating in this way the cost of roasting is involved, and an additional loss due to the fact that if such roasting be deferred until the zinc smelter is reached, the sulphur can then be utilized in the manufacture of sulphuric acid. At Leadville and at Broken Hill the ore is not roasted, it being the zinc that is pulled out as the magnetic product, the iron sulphides remaining behind as the non-magnetic product. There is reason to think that this would be the better commercial way of doing it in British Columbia in those cases where the zinc sulphide is sufficiently ferruginous to permit it. Such is usually the case where the zinc is black, or, as the miners speak of it, "black-jack."

Third in commercial importance has been the separation of manganese. Manganese, as is generally known, is used in the manufacture of Bessemer steel, to which it is added in the form of ferro-manganese or spëigeleisen for the purpose of reducing the oxides formed by overblowing the charge. For the purpose of making ferro-manganese the commercial requirements are for an ore that carries 50 per cent. of manganese. The tonnage of ores of this class is rather limited, while there is an enormous tonnage which carries from 5 to 15 per cent. of manganese. This is too much manganese to permit the ore being used as an iron ore, and it is not enough manganese to enable the ore to be used for the production of ferro-manganese. The magnetic separator enables the owner producing material of this character, to separate it into two products, one a 50 per cent. manganese ore, and the other an iron ore carrying 2 to 3 per cent. in manganese, so making out of an unsalable product, two products, both of which find sale. In this separation either the manganese or the hematite may be the more magnetic product, depending on the local peculiarities of the ore handled.

The magnetic separation in which Canada is especially represented is the cleaning of corundum. A commercial sample of Canadian corundum purchased in Chicago, was found to contain something over 10 per cent. of magnetite. Passing this over a magnetic separator, the magnetite was reduced below 3 per cent., the change representing an increase in the corundum contents from 89 to 97 per cent. Further experiments along this line seem to indicate that if desired, the iron could be sufficiently removed from the aluminium oxide to render corundum a possible ore for the smelting of aluminium.

The attractability of hornblende has been utilized in connection with the concentration of metallic copper. In

ores of this character the gangue, which was almost entirely hornblende, was pulled away as a magnetic product from the copper, leaving a copper ore which was sufficiently rich to smelt directly for copper, although the original ore carried less than 1 per cent. of copper.

Another interesting separation has been the handling of mica as a magnetic product. This may be utilized in two ways, for the extraction of mica from other material as an impurity and also for the concentration of mica for use in making mica insulating materials.

Of all recent developments of the magnetic separating methods, the more important is the fact that the cost of such separation is now generally below that of the equivalent water concentration, so that even in cases where water concentration is particularly adapted technically, as in the separation of chrome ores from serpentine, the magnetic method still proves the better commercially. It was this very low cost of magnetic separation that enabled concentration to succeed in the enrichment of hematite after water methods had failed commercially.

One fact of advantage in magnetic separation is that it can be made, as desired, either wet or dry. It occasionally happens that the freight on moisture contained in an ore shipment to a smelting point is a sufficient item to warrant drying it. In this case if the ore is sufficiently dry as it comes from the mine, the magnetic separation can be made dry, saving the cost of drying. On the other hand, if moisture in the ore is immaterial, either from freight considerations or from the smelter's standpoint, and it occurs in a wet mine, it is possible to put it through the magnetic separator without drying, shipping the product as it occurs. This is of special importance in connection with the St. Lawrence magnetite sands. The cost of drying that material before separation would probably prohibit its commercial utilization. As it is, such sands can be dredged up by any economical form of suction or dipper dredge and sluiced through a machine with an adequate supply of water, and produce a concentrate which can be drained to less than 15 per cent of water without artificial heat.

According to the monthly summary of commerce and finance prepared by the Department of Commerce and Labor, the value of electrical machinery exported from the United States into Canada increased from $178,160 in 1898, to $1,238,499 in 1903.

Aluminium Electrical Conductors

By RODERICK J. PARKE

From a Paper Read before the Canadian Electrical Association

THE use of aluminium for electrical conductors has grown to an extent which makes the consideration of its possibilities imperative when designing any system of distribution.

It is so far the only material which possesses the requisite properties to make practical its substitution for copper. Previous to 1898, aluminium was little known in the commercial world, but since that year, when it was first placed upon the market in the form of solid drawn conductors, the consumption has rapidly increased until in 1902, the date of the latest complete statistics available to the writer, the world's product was estimated at 8000 tons per annum. The corresponding production of copper is estimated at 497,000 tons per annum for all purposes. The statistics available up to the present, however, show that the production and consumption of aluminium are rapidly increasing and that it has become a very strong competitor of copper for electrical conductors.

There are now nine plants in the world producing aluminium, of which three are in America, two in France, and one each in Great Britain, Germany, Switzerland and Austria. The total power utilized in the production of the aluminium is from 36,000 to 40,000 H. P., practically all water-power.

The following figures are for commercial aluminium and commercial copper of sizes commonly used in practice, the copper being hard drawn:—

	Aluminium.	Copper.
Specific gravity	2.68	8.93
Conductivity (Matthiessen standard)	62.00	97.00
Tensile strength (per sq. in.)	28,000	45,000
Coefficient of linear expansion	.0000128	.0000093
Coefficient of temperature resistance	.00114	.00117
Modulus of elasticity	9,000,000	14,000,000

Using the above figures we find that the cross section of aluminium will have to be $\frac{97}{62}$ or 1.564 times that of copper to have the same resistance per foot. The weight of aluminium will therefore be

$$\frac{2.68 \times 1.564}{8.93}$$

times that of the copper, or 0.47.

The tensile strength of the aluminium will be

$$\frac{28{,}000 \times 1.564}{4500}$$

or 0.96 that of the copper.

The diameter of the aluminium will be 1.25 that of the copper.

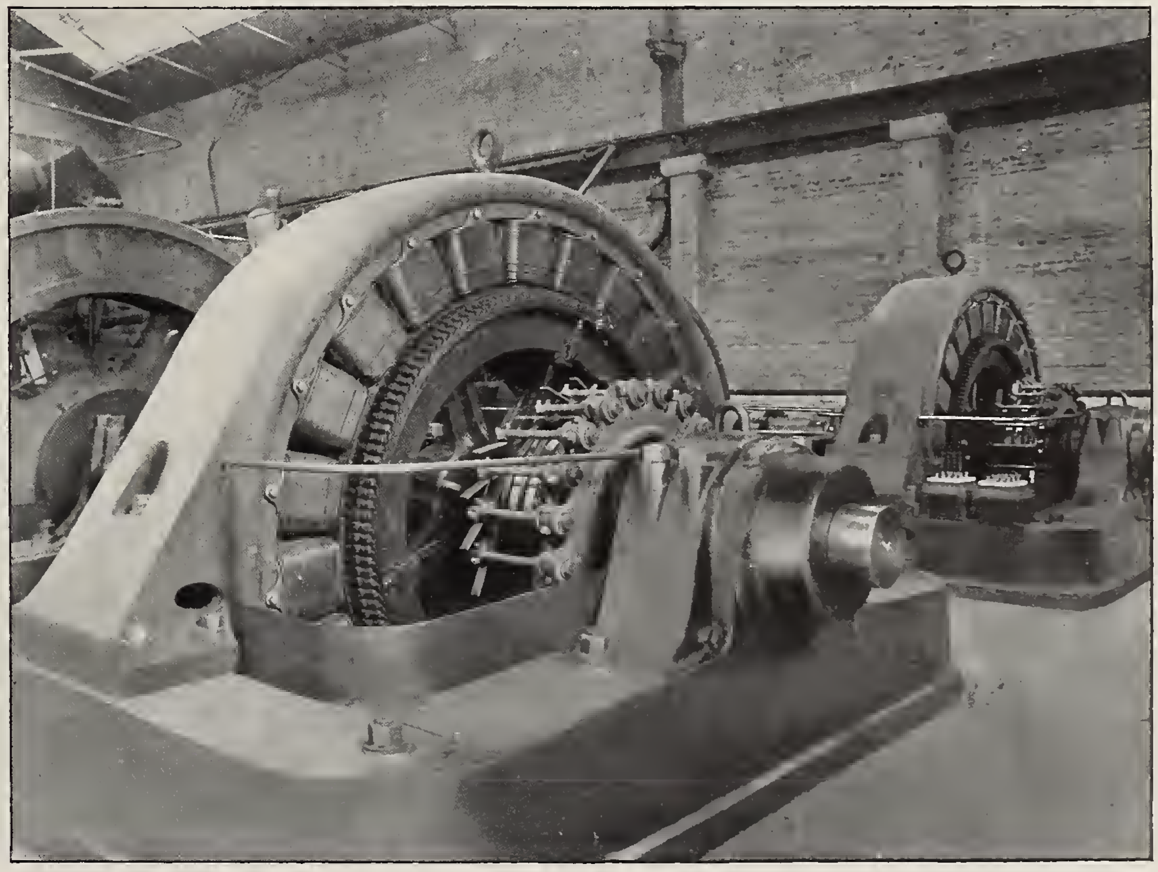


FIG. 22.—WESTINGHOUSE THREE-PHASE GENERATORS IN THE POWER STATION OF PALMER'S SHIPBUILDING AND IRON COMPANY, LTD., SEE PAGE 218

The price of aluminium for equal cost would be

$$\frac{1}{0.47} \text{ or } 2.13.$$

Tabulating these results we have:—

	Aluminium.	Copper.
Cross section for equal resistance	1.56	1
Diameter for equal resistance	1.25	1
Weight for equal resistance	0.47	1
Tensile strength for equal resistance	0.96	1
Price for equal cost	2.13	1
Rate of temperature change (resistance)	1.00	1

By inspection of the above table we see at once that the principal difference which exists from an engineering standpoint is that aluminium possesses less than half the weight of copper for equivalent resistance. This is a marked advantage and results in benefit in three ways:—

First.—The cost of transportation of aluminium is less than that of copper.

Second.—The cost of erection of the aluminium is less.

Third.—The durability of the line is greater and cost of maintenance is less on account of the smaller strains to which poles, crossarms, pins and insulators are subjected.

An additional advantage of aluminium is that on account of its peculiar nature it retains for years some of the grease used in drawing, and this grease prevents any great amount of sleet from forming upon it, thus avoiding one of the serious causes of interruption to service over pole lines. This result is rather surprising and its announcement is often greeted with incredulity, but the fact has been noted often enough to be well established.

To balance the advantages cited there are the following disadvantages:—

First—Difficulty in making joints.

Second—Greater sag due to larger coefficient of expansion.

Third.—Insufficient strength for conductors of the sizes used for telephone and telegraph wires.

Referring again to the question of sleet affecting metallic conductors, the writer was informed by a friend of his, who is an electrical engineer for one of the large companies in the United States, of a very practical illustration. He states that he was called to Kansas City to make an inspection of the Kansas City and Leavenworth Railroad. He happened to get there on a day when a very severe sleet storm was in progress, and he found the copper wires so badly covered with sleet that it was almost impossible to run the cars, and they were running scrapers instead of trolley wheels and were compelled to keep a man on top of the car to assist in knocking ice from the wire.

On the other hand the aluminium feeders, located on poles adjoining the tracks, were entirely free from sleet, and he states that this condition was not due to the fact that the wires were carrying sufficient current to warm them, because that was not the case, as there was only one car on the line between the power house and the part of the line referred to, and the feeder system was of ample size, so that the temperature rise was insufficient to have any effect in preventing the formation of sleet. In addition to this there would be from half an hour to an hour at a time when no car would be on the line at all, and then no current whatever would be passing over the line.

It does not follow, however, that sleet will never gather on aluminium wire anywhere, because in the neighborhood of railroads and manufacturing plants the wires are likely to become coated with smoke or some other foreign substance, upon which the sleet will form. In general, however, it may be safely assumed that sleet does not form upon aluminium wires.

The difficulty of soldering aluminium is well known, and, while it can be done, the operation in the majority

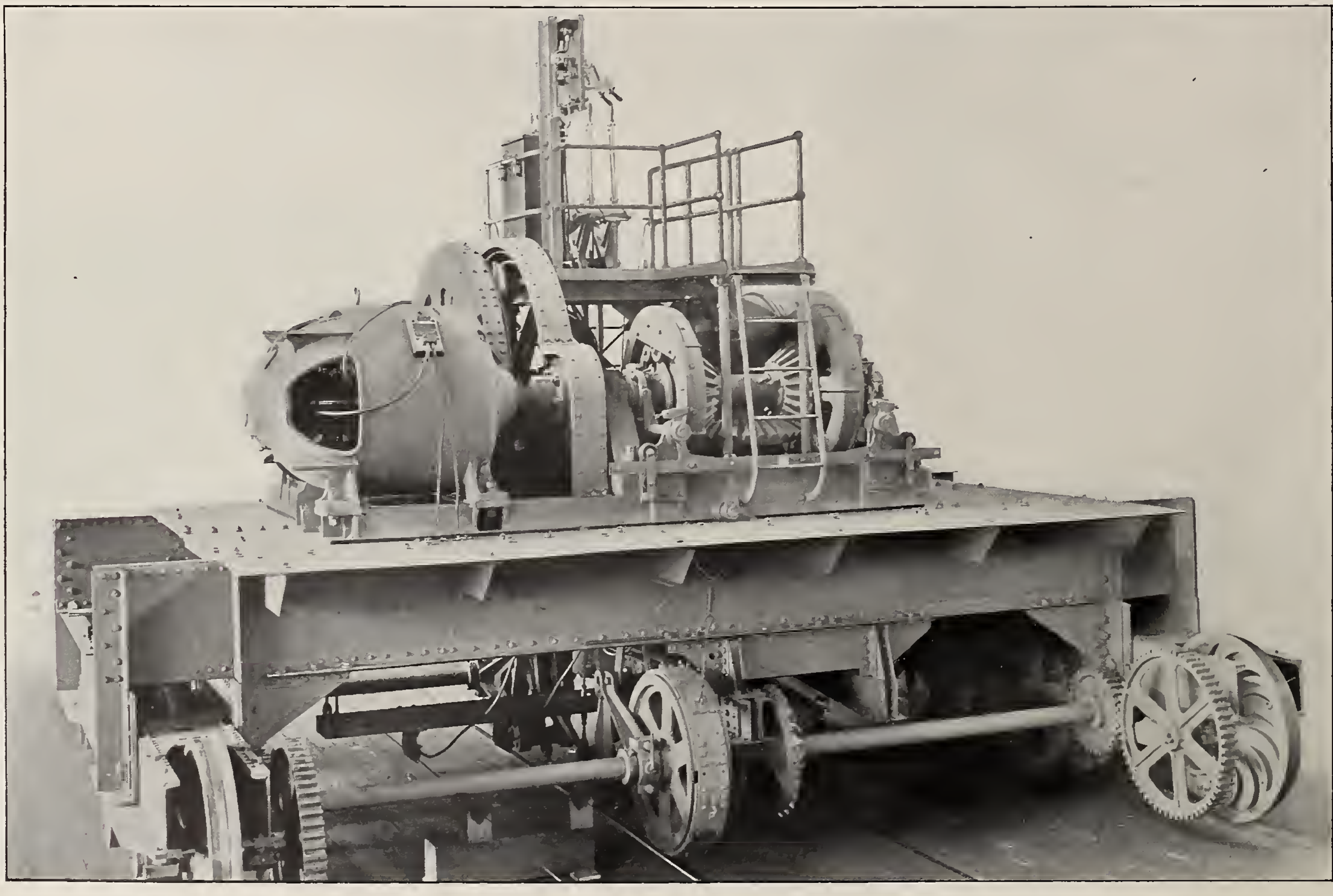


FIG. 23.—MOTOR AND TRAVELING CARRIAGE OF A CANTILEVER CRANE AT THE YARDS OF MESSRS. R. STEPHENSON & COMPANY, LTD., HEPBURN-ON-TYNE, MADE BY THE BROWN HOISTING MACHINERY COMPANY, LONDON, AND CLEVELAND, OHIO, U. S. A. SEE PAGE 217

of cases is attended with so much difficulty that unsoldered joints are preferable. The difficulty in soldering arises from three causes:—

First—Because solder does not alloy with aluminium at a low temperature. It will alloy with copper at approximately 460 degrees F., but the alloying temperature with aluminium is about 200 degrees F. higher.

Second—Because of the high thermal conductivity of aluminium the latter metal conveys the heat away very rapidly from the solder and from the soldering iron, making it difficult to maintain a soldering temperture.

Third—When aluminium is exposed to the air a thin invisible coating of oxide instantly forms upon the surface, although in this respect aluminium is not different from all other metals, because the surface of any metal becomes covered with its oxide immediately after exposure to the atmosphere. It is well known that it is necessary to remove this oxide coating in order to permit of the formation of an alloy between the solder and the metal, because the alloying can take place only on a clean surface of metal and the interposing film of oxide prevents the solder from coming into actual contact with the metal. In regard to metals other than aluminium, the oxide coating can be dissolved by means of soldering salts, but no such salt or flux, so far as the writer can learn, has been discovered for aluminium; hence the difficulty in soldering it. Attempts have been made to use various materials as fluxes to remove the oxide coating of the aluminium, but the results have not been satisfactory, and, in fact, have been in most cases detrimental to the aluminium because of the resulting formation of a chemical compound which interferes with soldering instead of facilitating it.

For joining aluminium wires smaller than No. 0000 B. & S. gauge the two ends are inserted into a piece of flattened tube and the tube given two and one-half twists by means of two pairs of ordinary wire connectors. This makes a perfectly satisfactory joint of low resistance and as strong as the wires joined.

Larger sizes are conveniently joined in any of three ways:—

First—By means of the ordinary dovetail cable splice. (The Niagara Falls-Buffalo line, consisting of 500-000 circular mils aluminium cable, is joined in this way, and has been in use for several years and has given perfect satisfaction.)

Second—By means of terminals compressed on the ends of the cables at the factory, these terminals being threaded and thus adapted to be united in the field by a threaded stud.

FIG. 24.—ANOTHER VIEW OF THE SAME CARRIAGE, SHOWING THE SWITCHES AND CONTROLLERS SEE PAGE 217

Third—By inserting the ends to be joined into a cast sleeve and compressing the sleeves between dies in a small portable press.

Taps are made by means of aluminium clamps, one of which carries a lug into which the tap wire is either soldered or secured by set screws. Soldering into a lug is one of the pieces of aluminium soldering which can be readily accomplished.

It will be seen from the above that the difficulties of making aluminium joints have been reduced to an extent which leaves almost no disadvantage whatever.

The sag of aluminium conductors is somewhat greater than that of copper in hot weather and on ordinary spans on account of the fact that the coefficient of expansion of aluminium is 38 per cent. greater than that of copper.

The sag is not so much greater as might be expected, however, because the lower modulus of elasticity of aluminium causes it to contract more as the strain is relieved from it and because the weight of aluminium, for equal areas, is only three-tenths that of copper, while the strength of it is two-thirds that of copper. This causes aluminium to start with a smaller minimum sag than copper.

One curious result of this is that whereas aluminium will have a maximum sag of 3 or 4 inches more than copper in a 100-foot span, it will have actually a smaller maximum sag in a 1000-foot span, for while the span moves farther or deflects more rapidly than copper for a given temperature change, it starts with so much smaller sag at low temperature that it never overhauls the copper when long spans are used. On this account and that of its small weight, it would seem to be the best material for long-span work.

The use of a reliable dynamometer for stringing aluminium wire is strongly recommended, as experience seems to indicate that it is a difficult matter to obtain linemen experienced in handling the wire or who can be depended upon to provide that proper sags shall be set when stringing the wire. The use of the dynamometer does not involve any greater expense for the stringing of aluminium conductors than its non-use when stringing copper conductors, because, owing to lighter weight of the former, the

material can be handled much more easily and quickly than the copper can size for size.

The third objection for aluminium applies only to telegraph and telephone lines and similar work. The smallest

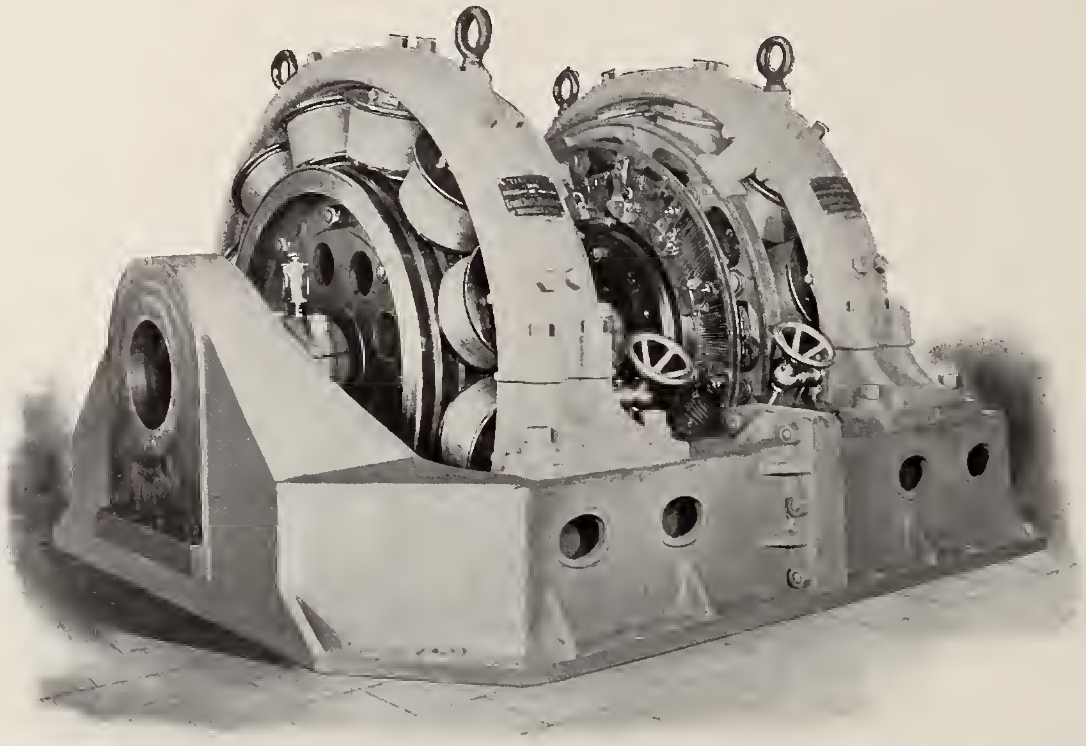


FIG. 25.—TWO 140-H. P. CONTINUOUS-CURRENT MOTORS MADE BY MESSRS. ERNEST SCOTT & MOUNTAIN, LTD., NEWCASTLE-ON-TYNE, USED FOR DRIVING CENTRIFUGAL DOCK PUMPS AT THE BLYTH SHIPBUILDING COMPANY'S DRY DOCK, AT BLYTH

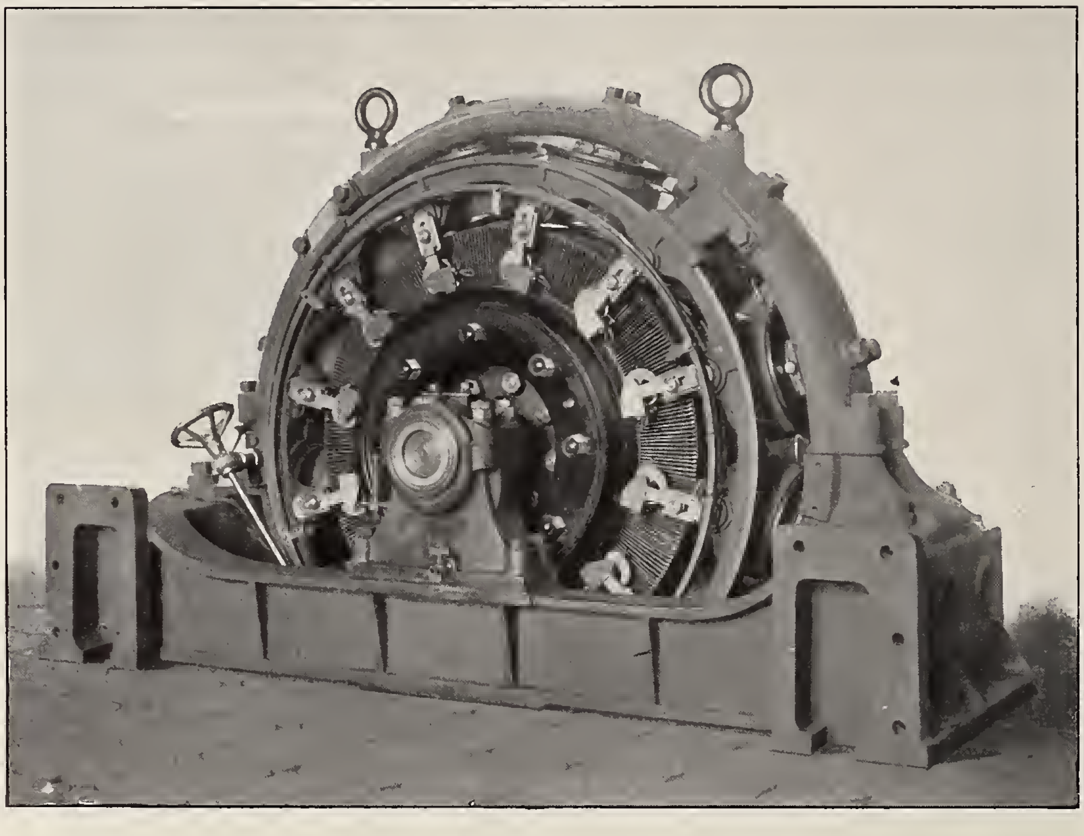


FIG. 26.—A VIEW OF ONE OF THE MOTORS IN FIG. 29, SHOWING THE COMMUTATOR AND BRUSH GEAR. SEE PAGE 219

size of aluminium wire which it would be advisable to use in pole-line work is No. 4 B. & S. gauge, which has a breaking strength of about 1000 pounds, which is the minimum strength that should be allowed in any conductor on a pole line if uninterrupted service must be given over it.

The principal uses of aluminium conductors have been for railway feeders, high-tension transmissions and bus-bars. Its use in Canada has not been very extensive, due to the fact that the beginning of its manufacture there is of rather recent date. But there are very few places in the United States where it is not found in service. Very little need be said about its use for railway feeders, which have absorbed nearly two-thirds of what has so far been used. This use, however, presents no problems with which engineers are not familiar. For power transmission its use has become very extensive. The longest and largest transmissions in the world are now made over aluminium. From information furnished me by one of the manufacturers of aluminium conductors I have selected the following list and data which may be of interest:—

Location.	No. of Cables.	Miles Per Cable.	C.M. Area of Each.
Niagara Falls to Buffalo.	3	20	500,000
Shawinigan Falls to Montreal	3	85	183,708
Electra to Mission San Jose	3	100	471,034
Colgate to Oakland.....	3	144	211,000
Farmington River to Hartford	3	11	336,420
Lewiston, Me.	3	3.5	144,688
Ludlow, Mass.	6	4.5	135,247

In addition to the foregoing list the lines of the Telluride Power Transmission Company in Utah, Colorado and Montana use nearly 2000 miles of wire, involving transmission distances of 130 miles.

The question of the durability of aluminium conductors has frequently been raised since they have been brought into active competition with copper, but so far the information available shows that aluminium has thoroughly established itself as a conductor material offering no disadvantages which are not, in other respects, proportionately found in regard to copper or iron. Aluminium is not readily oxidizable, and the greater number of mineral acids seem to have no chemical effect upon it, but chlorine in any of its unstable combinations is more or less detrimental to it, particularly where the conductors are exposed to sea air or where they are installed within the vicinity of certain chemical works.

On the other hand copper is liable to be detrimentally affected by atmospheres laden with acid fumes; consequently it would hardly be fair to condemn aluminium for lack of permanency any more than it would be to condemn copper. The most common impurity of aluminium is sodium, which forms a very unstable alloy, readily attacked and corroded in even slightly moist atmospheres. This defect can be provided against by the manufacturers, and no doubt the consumer can depend upon the purity of aluminium furnished by any responsible manufacturer as readily as he can depend upon the guaranteed qualities or characteristics of copper purchased from any responsible copper manufacturer.

Aluminium conductors were first placed on the market in the form of solid drawn wire, and in this form a considerable quantity of it was installed on transmission lines. Subsequent experience demonstrated that the tensile strength of any given aluminium conductor is increased somewhat by building it up of several smaller strands wound together, and

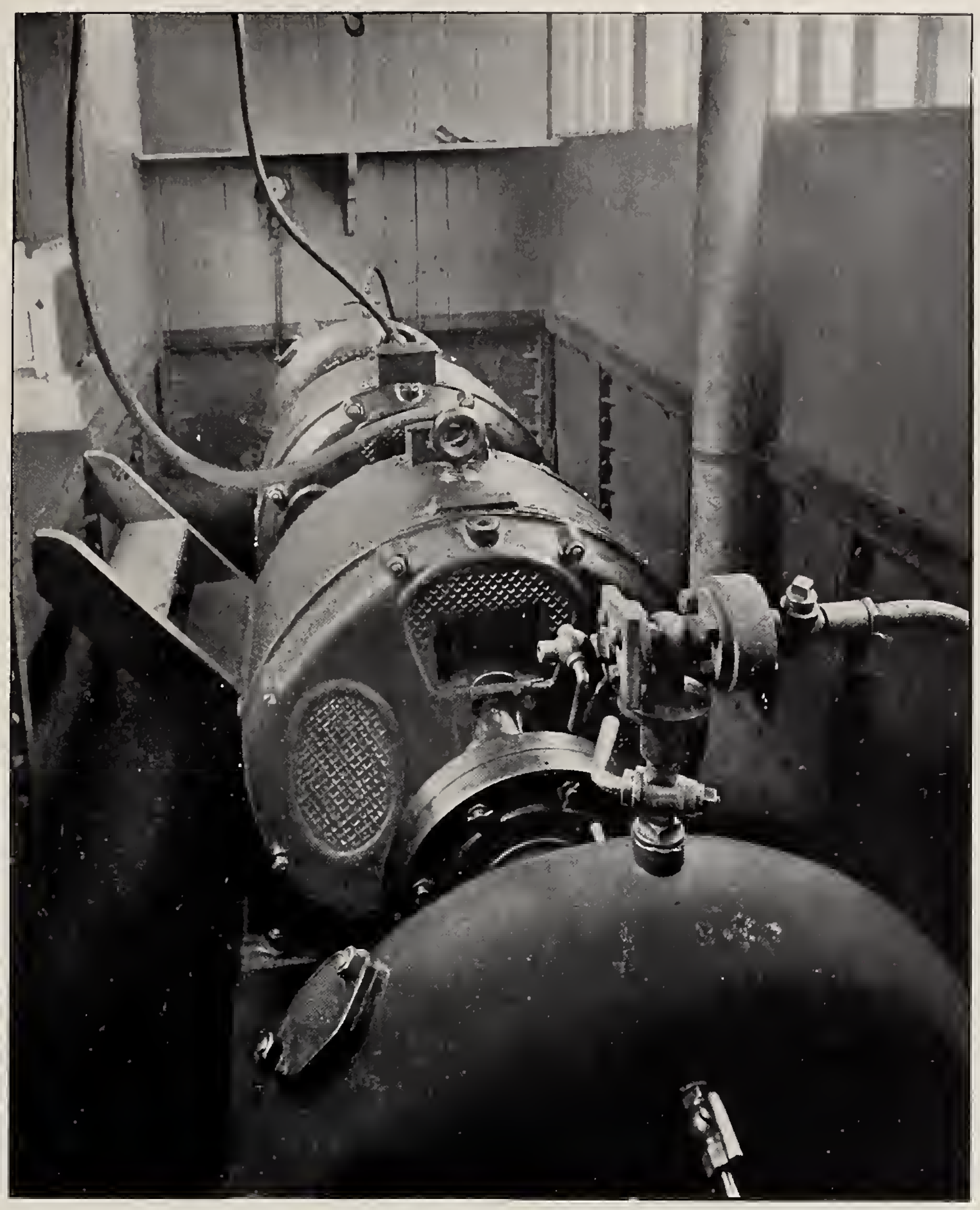


FIG. 27.—WESTINGHOUSE THREE-PHASE INDUCTION MOTORS DRIVING CIRCULATING PUMPS FOR CONDENSING PLANT AT THE YARD OF PALMER'S SHIPBUILDING AND IRON COMPANY, LTD., JARROW-ON-TYNE

since this form has been adopted the writer has not been able to learn of any instances in which the conductors have broken on account of deficient tensile strength, where they have been properly installed.

In connection with the installation of the electric lighting and power distribution system along the Welland Canal, this work being now in progress, the Government purchased a quantity of aluminium and copper conductors for the transmission and distributing circuits.

The writer's specifications called for No. 0, No. 2, No. 4, No. 6 and No. 10 B. & S. copper conductors, the No. 6 B. & S. to be medium hard-drawn and the No. 10 to be hard-drawn. Tenders were also taken, as alternative, for the supply of aluminium conductors of conductivities equivalent to those of copper conductors specified, and on comparing tenders it was found that the No. 000, No. 0 and No. 2 B. & S. aluminium conductors offered as equivalents for the No. 0, No. 2 and No. 4 copper would cost less than the copper, and the aluminium was purchased. The aluminium equivalent for No. 6 copper, taking into consideration the tensile strength specified for the medium hard-drawn copper, was found to be more expensive than the copper, consequently copper was purchased for the No. 6 and No. 10 gauges. The writer desires to explain that the gauge numbers just mentioned for the aluminium conductors do not represent the correct relative proportions as compared with copper, but are the nearest gauge numbers corresponding to the area of the aluminium conductors representing the copper equivalent.

The writer tested a proportion of the aluminium conductors for cross-section, tensile strength, torsion and resistance, and found the results given in the table below:—

Approximate Gauge.	Number of Strands.	Approximate Gauge of Strands.	Twists in 6 Inches.	Breaking Strains Per Sq. In.	Per Cent. Elongation in 6 Ins.	Resistance Per 1,000 Ft. at 75° F.
000	7	7 B. & S.	21	29,100	2	.106
0	7	9 B. & S.	22	33,000	2⅔	.172
2	7	10 B. & S.	30	35,500	3⅓	.262

The above-mentioned results of the tests seem to show that the tensile strength increases somewhat with a reduction in area of the smaller strands composing the conductor.

Also it will be seen that the conductivity of the aluminium conductors as compared with that of pure copper conductors of the equivalent smaller gauges specified is approximately 99.3, 98.5 and 99 per cent., respectively, and the respective breaking strains of the aluminium per square inch exceed the breaking strain usually allowed for soft copper (pure), namely, 23,600 pounds.

The questions are often asked with relation to alternating-current work as to the respective capacity, self-in-

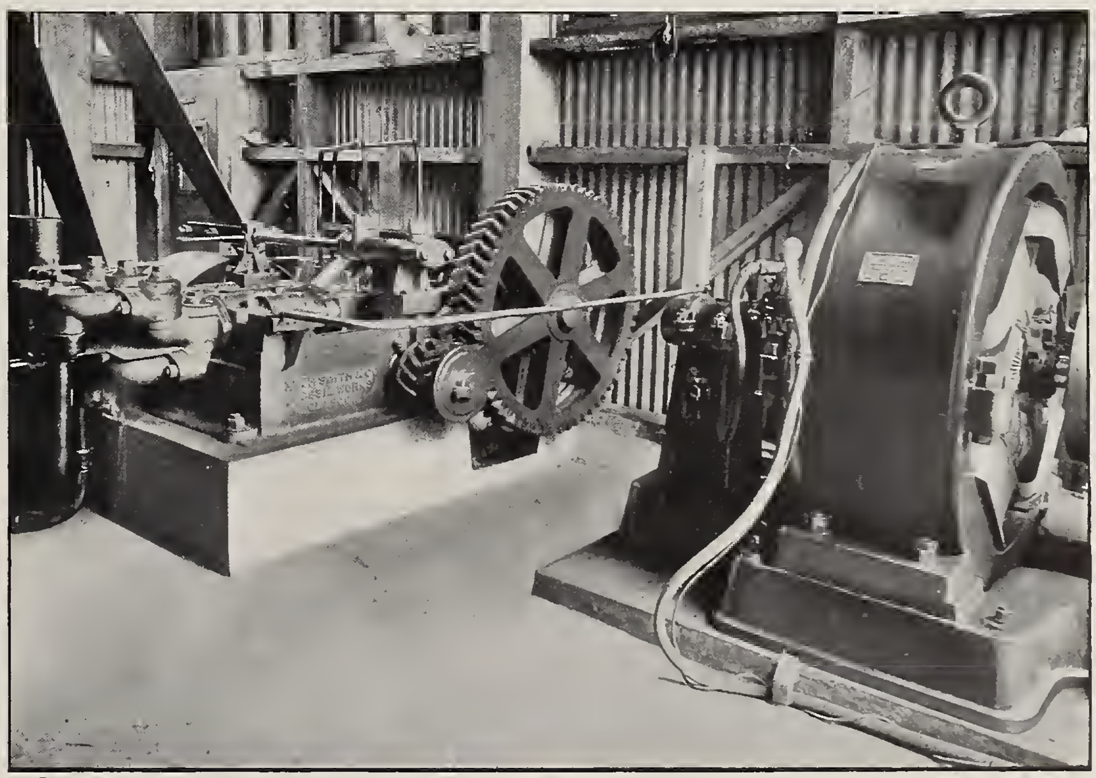


FIG. 28.—A MOTOR-DRIVEN THREE-THROW PUMP FOR CHARGING HYDRAULIC ACCUMULATORS AT THE YARD OF MESSRS. FURNESS, WITHY & CO., LTD., HARTLEPOOL. SEE PAGE 217

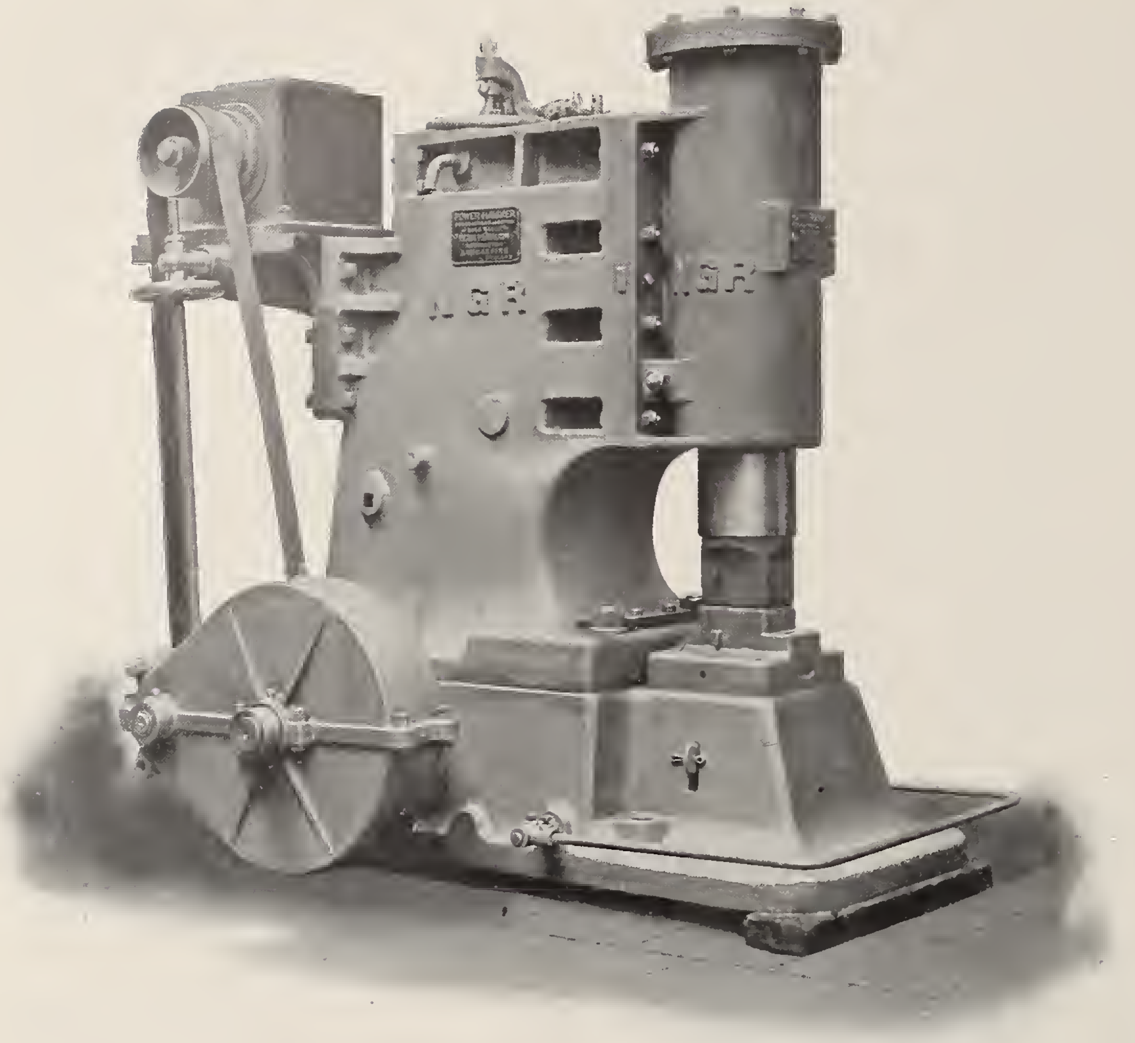


FIG. 29.—AN ELECTRICALLY-OPERATED HAMMER MADE BY PETER PILKINGTON, LTD., ACCRINGTON. A 16-H. P. MOTOR IS USED. SEE PAGE 218

duction and skin effects of aluminium and copper.

As aluminium is one-quarter greater in diameter than equivalent copper, it is evident that the self-induction of the line will be the same when the aluminium wires are separated 25 per cent. more than the copper wires.

The static capacity of the aluminium will be approximately 5 per cent. greater than that of copper with the same spacing.

The skin effect will be exactly the same with either of the two metals, since the effect of the greater diameter of the aluminium is exactly offset by its greater specific resistance in making the calculations for the per cent. increase of resistance.

All practical transmission lines possess sufficient excess of self-induction over capacity to cause a slight lag in alternating currents, and the power factor over an aluminium line would therefore be slightly better than that over a copper line on account of the smaller self-induction and greater capacity. The difference is small, but what there is is in favor of aluminium.

The market prices of aluminium and copper have always been such for the last five years that from 5 to 15 per cent. can be saved by the purchase of aluminium.

For instance, the present market price of copper is about 14 cents. An equivalent price of aluminium would be 29.8 cents, whereas aluminium can be had to-day for 27.5 cents, or the equivalent of 13-cent copper.

In view of all the facts it would seem that we are no longer compelled to confine ourselves to a single material for carrying current, as was formerly the case.

British Rules for the Use of Electricity in Mines

At a recent meeting of the Institution of Mining Engineers in London, Mr. S. F. Walker discussed the report of the departmental committee on the use of electricity in mines. The special rules proposed by the committee were, in Mr. Walker's opinion, too lengthy, and they consisted very largely of what was merely advice impossible to enforce. Furthermore, the rules made a clear interpretation as to the colliery manager's work impossible, and in many of the rules terms were used which are unfamiliar to mining engineers.

Mr. Walker has, therefore, submitted the following special rules of his own, in which, he says, the committee's views are embodied, though in a somewhat different and simpler form:—

1. Pressures exceeding 3000 volts shall not be used anywhere in or about a mine, and pressures above 650 volts shall not be used outside the main intake airways, or chambers supplied directly from the main intake airways without the permission in writing of the inspector of mines in charge of the district.

2. All machine-carcases, cases enclosing switches and fuses, and any other metals (excluding nails and screws) used to protect, or to support conductors belonging to the electrical service, but not in conductive connection with the service, shall be connected to earth, except in cases specially exempted by the inspector in charge of the district.

3. No part of the conductive system of an electrical service at a mine shall be connected to earth, except by special permission of the inspector of mines in charge of the district.

4. All electrical apparatus in use at a mine shall be so fixed and maintained that in the ordinary working of the mine:—(*a*) No part of the apparatus shall become unduly heated; (*b*) no arc shall be formed in any part of any apparatus, and (*c*) it shall not be possible for those using or engaged in the use of the apparatus to get a shock, while carrying out their duties in a proper manner.

5. All cables and machinery shall be tested not less than once a week for insulation, with a current whose pressure is not less than that of the working current, the tests being recorded in a book provided for the purpose, and the insulation of the whole of the apparatus must be maintained in such condition that the leakage current at any instant is not greater than 0.0001 of the maximum total current.

6. All connections between service cables and generators, motors, transformers and lamps shall be properly controlled by switches and protected by fuses or electro-magnetic apparatus, in such manner that No. 4 rule is fully complied with, and all switches fuses and junctions between cables and any places where the circuit is made and broken, shall be enclosed in gas and flame-tight boxes. Where trailing cables are used in connection with machinery in motion, or for shot-firing, a connection shall not be made with the supply service until a connection has been made with the motor

or fuses, and everything arranged, and no electric motor shall be worked in an explosive atmosphere.

In discussing these rules Mr. Walker is of the opinion that the first special rule enacts all that is necessary about the use of pressures, and it is specially drawn so as not to cramp the development of the use of electricity in mines. Probably it will be some time before it becomes economically advantageous to use pressures exceeding 3000 volts, while on the other hand it is not difficult to imagine some engineer, who may have been appointed to a colliery with an imperfect knowledge of engineering, using higher pressures without necessity and without economy. There is nothing in the committee's proposed special rules to prevent his doing so provided that he uses motors of 75 H. P.

The provision that only 650 volts shall be used outside the main intake airways also ensure safety, while the provision that the inspector of mines may allow higher pressures in both cases, allows of expansion with increased knowledge and experience. The writer is also of opinion that the provisions necessary to ensure safety from shock above a pressure of 250 volts, are equally necessary below it. There have been deaths in towns with 200 volts and less, under conditions apparently very much more favorable to the victims than will often exist in a mine. The time factor has an important bearing on the subject; even 100 volts will kill if time be allowed, and it has been shown that 5000 volts may not kill if the victim's skin is burnt quickly so as to block the passage of the current through him.

The second rule suggested by Mr. Walker embodies the views of the committee repeatedly expressed in their report and the proposed special rules. On the other hand, it is open to grave objections in many cases, and the idea is that these cases should be represented to the inspector of mines. The third rule also embodies the views of the committee.

The fourth rule comprises the different instructions which run through the special rules proposed by the committee, but it differs from the method of the committee in that while strictly enforcing arrangements that ensure safety, it refrains from attempting to say how they shall be carried out. The provision that no part of an electrical apparatus shall be unduly heated, is, it will be seen, very far reaching. To ensure that this is so, the engineer must follow certain rules with regard to the density of current in the cables, the insulation of the cables, the size and arrangement of the switches, fuses and junctions; and in the size and insulation of the conductors in the generators, motors, etc. He must also provide proper measuring instruments. In fact he has to design and maintain the apparatus as well as the state of knowledge at the time allows.

The writer has purposely refrained from specifying that a certain rise of temperature must not be exceeded, as in his view this would hardly meet the case of the greatly varying conditions of mine working, varying air-currents, varying loads, varying time of working, etc. He is of opinion, as already indicated, that the inspector of mines would be the guide. If he saw a motor in his opinion working too hot, he would call for it to be altered. In the matter of density of current in cables, economy in transmission will generally rule a low density, but again the permissible densities vary very considerably with the conditions. In a powerful air-current, cool from the surface, a comparatively high density may easily be quite safe, while the density allowed by the special rule proposed by the committee might be unsafe in others. Personal observation must be the guide in these matters.

The second section (b) of the fourth rule is really a part of the first section (a), but it is placed by itself so as

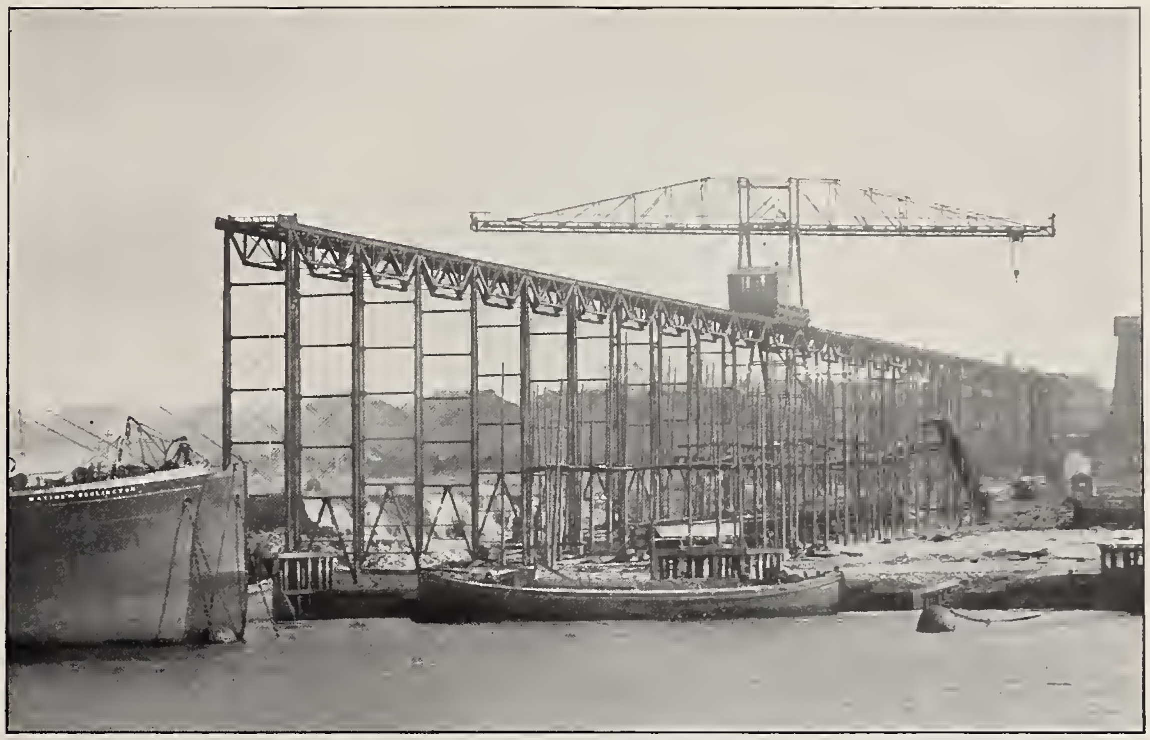


FIG. 30.—A DOUBLE CANTILEVER ELECTRIC CRANE BUILT BY THE BROWN HOISTING MACHINERY COMPANY, LONDON, AND CLEVELAND, OHIO, U. S. A., FOR THE SHIPYARD OF MESSRS. R. STEPHENSON & CO., LTD., HEPBURN-ON-TYNE. SEE PAGE 217

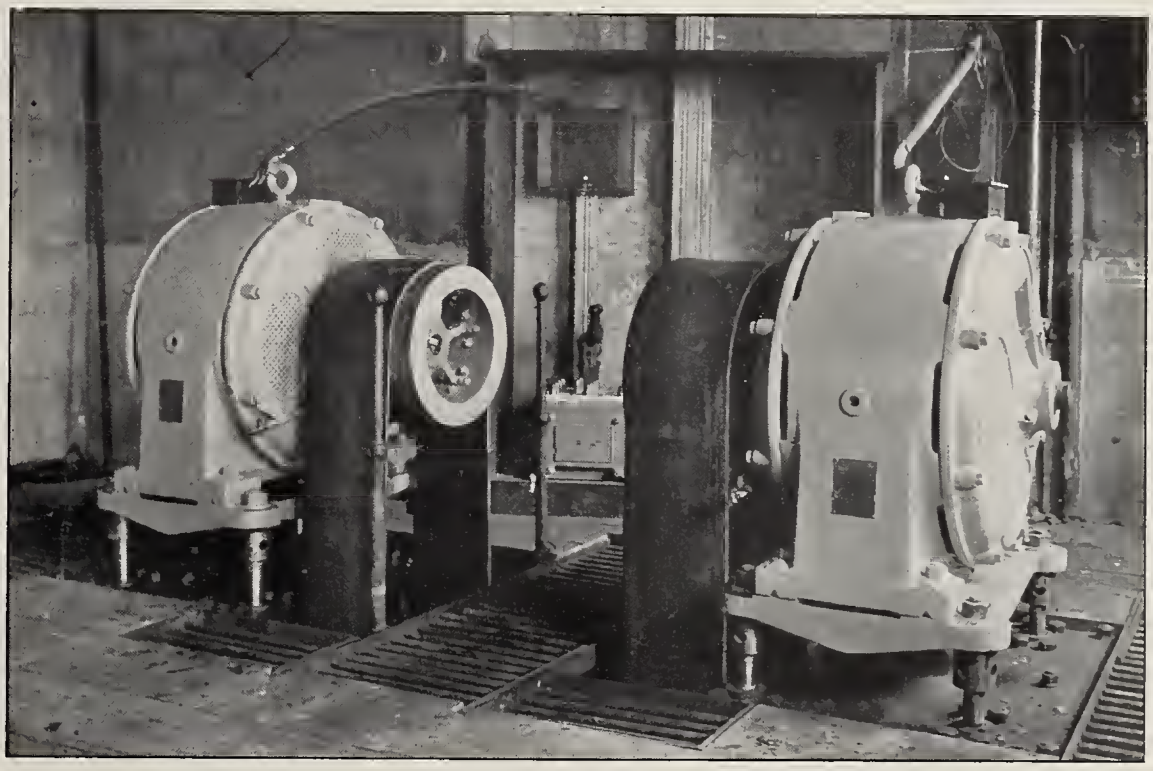


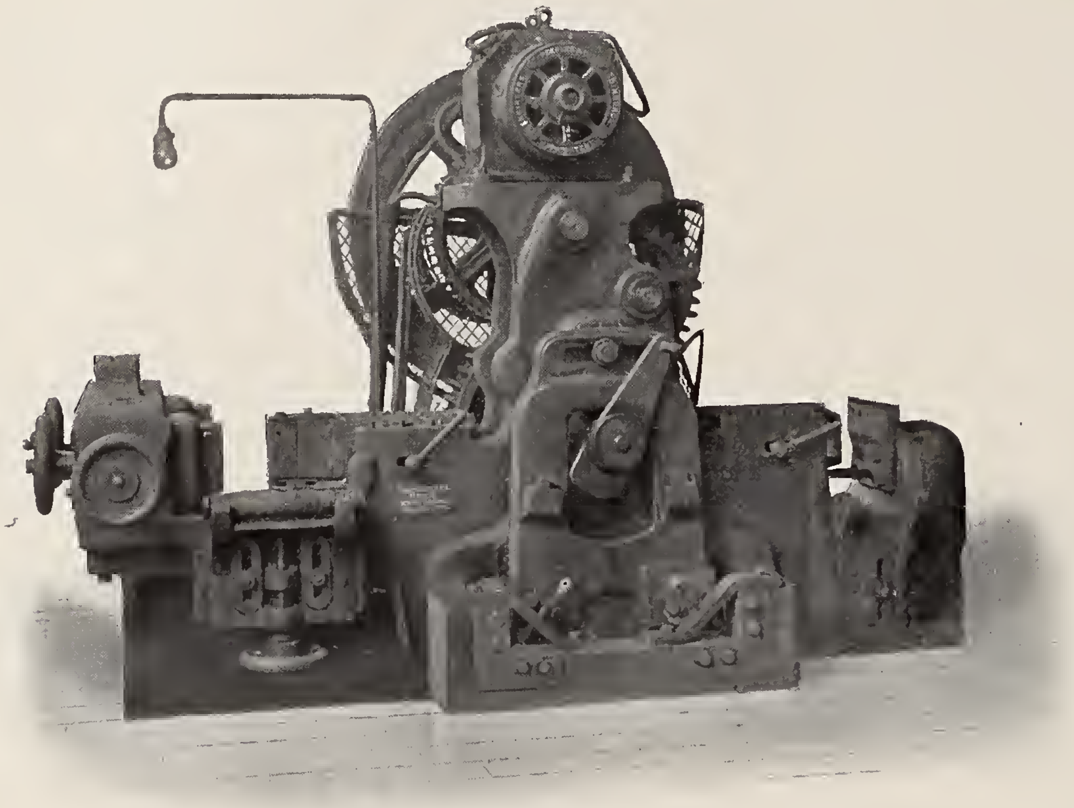
FIG. 31.—WESTINGHOUSE THREE-PHASE INDUCTION MOTORS OF 50 H. P. EACH, DRIVING DRY DOCK PUMPS AT THE YARD OF PALMER'S SHIPBUILDING AND IRON COMPANY, LTD., JARROW-ON-TYNE. SEE PAGE 218

to direct especial attention to it. The rules for guarding against arcing in electrical apparatus are now well known, and the test would be in practice. A provision that fillets shall be fitted or that a certain distance shall exist between certain parts will not be sufficient. An arc can be made over a very large distance with the aid of a deposit of copper or mine dust. Again, the idea is to show what should not be done, and to throw upon the colliery manager and his electrical adviser how it is to be done. The inspector of mines in charge of the district should be able to give valuable advice, as he would see different forms of apparatus, and what is of far more value, the different forms in which the same trouble may arise.

The third section (*c*) of the suggested fourth rule again embodies all that runs through the report of the committee and their special rules, but it also throws upon the colliery officials the onus of providing efficient means of carrying out the rule.

The fifth suggested rule provides all that the committee have aimed at, and the writer is of opinion that, if the provisions are carried out, there is no necessity for an "earth" indicating device. It is very doubtful, indeed, if it is wise to adopt the "earth" indicating device. It might very possibly introduce complications into the system, and if careful tests are taken periodically, and the measuring instruments carefully watched, ample warning will be given of any coming trouble. In all of these cases, it is common experience that the smallest number of "accidents" occur where the man in charge constantly watches his apparatus, and keeps in close touch with it, and this he would be able to do by means of the insulation tests and the measuring instruments.

It will be noticed that no mention is made in the suggested special rules as to how the cables are to be insulated, the insulation resistance, whether naked cables shall be allowed, nor of how cables are to be tested. The writer is of the opinion that all of the above requirements are provided for. Naked cables would be perfectly permissible in situations where there would be no liability to shock, and where the insulation can be maintained. How the cables are to be insulated and what tests are made on them before they are fixed, may also be left to the manager and his electrical adviser. Naturally the manager and his adviser and the manufacturer of cables will observe those tests which will ensure the cable having the longest life, so far as insulation is concerned. It will also be observed that the case of arcing or discharging between cables is provided for in the fourth suggested special rule.



ELECTRIC POWER IN BRITISH SHIPYARDS. FIG. 32.—ANGLE-IRON BENDING AND SHEARING MACHINE EQUIPPED WITH A 10-H. P. MOTOR BY MESSRS. BRUCE PEEBLES & CO., LTD., EDINBURGH

Mr. Walker, however, views with considerable disfavor the special rule proposed by the committee, providing that cables shall be tested with higher voltages than those to which they will be subjected in work. He is of the opinion that by so doing the insulation of the cable is strained, and deprived of a portion of its life as to insulation resistance, and resistance to sparking. Test a sample piece as much as you like, in whatever way you like, but do not strain the cable itself.

Objection has been taken to the quantity of the leakage current allowed. This is a matter that can be adjusted, but in the writer's opinion, the higher the standard that is fixed and the lower the maximum leakage current allowed, the better will be the apparatus work as a whole.

The sixth suggested special rule is really provided for in the other rules, but it has been thought desirable to add it, in order to emphasize the points previously mentioned. Again it will be noticed that this special rule, together with the others, provides all that is required in the matter of the control of motors, lamps, transformers, etc., but without specifying the method. Arcing, for instance, in a starting switch and overheating in a starting switch are equally forbidden, although the means of ensuring that they shall not occur are left to the judgment of the responsible officials.

The possible reversal of a generator when running in parallel is also forbidden, without stating that a reverse automatic cut-out is to be used. It would probably be wise, for some time to come, not to run generators in parallel in colliery electrical services, but where they are, reversal would lead to arcing and to heating, and is, therefore, forbidden. The last portion of the sixth suggested special rule provides for the case of fiery mines, and it also provides for the case of motors working in fiery mines, the commutator or the slip-rings being placed where the circuit is broken.

The special rule of the committee providing that the electric motor working coal-cutting machines shall only be run for a certain time, and shall be stopped when gas is present, is provided for by the suggested special rules against undue heating, and the clause of the sixth special rule, forbidding electric motors from working in an explosive atmosphere. The question of repairs and the disconnection of the service, while they are being done, is provided for by the rule against shock.

Mr. Walker believes that in the suggested special rules he has provided for all contingencies on the lines indicated, the responsibility of the manager, and the guidance of the inspector of mines.

The City Council of Kalk Bay Station, Cape Colony, South Africa, has been empowered to issue bonds for such amount as it may need to erect a municipal electric light and power plant.

Notes on European Testing Laboratories

By CLAYTON H. SHARP, Ph.D., Test-Officer of the Electrical Testing Laboratories, New York

A Paper Read at the Recent Newcastle (N. H.) Meeting of the Association of Edison Illuminating Companies

PERHAPS the most prominent, and certainly the most promising of English laboratories, is the National Physical Laboratory. This is situated in Bushy Park, a short distance outside of London, and not far from Kew Botanical Gardens and the famous old Kew Observatory. The situation is in many ways an excellent one, although even there they are disturbed by stray earth-currents and changing magnetic fields.

The building which is used as a laboratory is Bushy House, an ancient edifice of considerable extent, built with thick walls after the fashion of its time. From the point of view of construction, it is by no means badly suited to its purpose. As far as the arrangement of the rooms is concerned, it leaves a great deal to be desired. The director is Prof. Glazebrook, one of the best known English physicists, and co-operating with him is a small, though well-chosen, corps of assistants.

The equipment of this laboratory has been largely acquired through gifts of individuals and of engineering firms. For support it is largely dependent upon subscriptions from similar sources. As might be expected, the equipment is by no means a very large one; but that it has been carried out on a broad-minded basis is evidenced by the fact that this is the only one of the prominent laboratories in London and vicinity where there is any considerable quantity of the high-grade German apparatus which is so well known on this side of the Atlantic. In other words, its apparatus is not exclusively of British manufacture, good though the latter may be.

Besides commercial testing, very important investigations are being carried out in this laboratory, among which are the study of standard cells and the absolute determination of the ampere. The Electrical Testing Laboratories has been co-operating with the National Physical Laboratory in the matter of standards of light. The progress and development of a national laboratory of this sort is necessarily slow, especially when hampered by a lack of funds. The future may see this laboratory developed into a great institution, of which the British nation may well be proud and which will be of enormous value to British industries. It is still in the day of small things, but its promise for the future is bright.

The laboratory of the Board of Trade is, in contrast with the National Physical Laboratory, comparatively an old established institution, it having been established some years ago. It is situated in Whitehall, in a busy part of London, occupying a number of rooms in the basement of the building. The purpose of this laboratory is three-fold. First, to obtain and preserve standards for the measurement of electrical quantities; second, for giving the standard measurements of those quantities; third, to enable the electrical advisor of the Board of Trade to make such tests of instruments and material as may be necessary in the performance of his duties. The laboratory is under the direction of Mr. Trotter.

It contains a number of interesting instruments, including a special 1 am-Kelvin balance and a standard Kelvin electrostatic voltmeter for 100 volts. These instruments are legalized secondary standards in Great Britain. The standard balance is an elaborate affair, coinciding in principle with the Kelvin balances with which we are all familiar, but differs from them in arrangement and in the degree of refinement obtained in its use. It has been standardized by many measurements with the silver voltameter. It would seem as if the care and expense lavished on the construction of this instrument would have sufficed for the construction of an absolute instrument by which the ampere could be recovered without any previous calibration. It is not likely that any great laboratory will ever follow the example of the Board of Trade Laboratory as far as this instrument is concerned. The standard multicellular voltmeter is an electrostatic instrument which deflects exactly the distance between one mark and another when an E. M. F. of exactly 100 volts is impressed upon it. It has been standardized by passing 1 ampere, as shown by the standard ampere balance, through a resistance of 100 ohms. This 100-ohm resistance was measured by comparison with the British Association resistance standards, which are in the possession of this laboratory.

Besides the standard 1-ampere balance and the standard 100-volt voltmeter, the laboratory is equipped with a series of Kelvin balances running to 10,000 amperes capacity, and with a series of six electrostatic voltmeters covering the range from 2000 to 3200 volts. This latter arrangement is decidedly antiquated in view of the accuracy which is readily obtainable by the use of potentiometer and standard cell.

In this laboratory are carried out tests of meters submitted to the Board of Trade for its sanction and approval. In testing a direct-current meter the current is measured by passing it through a Kelvin balance. The voltage is measured by means of an electrostatic voltmeter. The dispatch with which three men are able to test a meter by the aid of these instruments is something which can be imagined quite as well as it can be described. For measurements of alternating-current power, Kelvin astatic direct-reading wattmeters are employed. For some of the more refined measurements, including comparisons of resistance and measurements of standard cells, a constant temperature room is used. This is simply one of the ordinary basement rooms, which is heated by a gas stove. The gas supply is automatically regulated by a thermostat. By this simple arrangement, the temperature in this room is maintained at about 60 degrees F. throughout the year, and it is constant within a couple of degrees, except occasionally in the summer time. The facility with which a moderate, low and constant temperature can be maintained in this way indicates that there are certain advantages possessed even by the London climate.

The London County Council maintains two laboratories under the direction of Mr. Gunyon for the checking of recording meters. One of these is in a small power house situated on the Thames embankment, supplying arc lamps on the embankment and on the

bridges. The other, older laboratory is quite near Trafalgar Square. In this laboratory the Kelvin balance is again the instrument with which direct currents are measured, although they have dispensed with the electrostatic voltmeter. The methods employed are, as will be seen, somewhat less cumbersome than those of the Board of Trade, but certainly the use of a few good Weston instruments would enable them to accelerate their work without any prejudice to its real accuracy.

The newer laboratory on the embankment contains a double alternator set, giving wide variation in periodicity by cone-pulley drive, together with mechanical adjustment of power factor by taking current for wattmeter testing from one alternator and pressure from the other while the armature ring of one of the machines is shifted to a suitable angle with respect to the other. This set is on the same principle as a set recently installed in the Electrical Testing Laboratories.

The City Corporation maintains, in Guildhall, a laboratory for testing meters and lamps. Photometry is done on a Reichsanstalt type photometer track placed under a black cloth awning. The practice is to use a standard lamp of the same voltage as the lamp to be tested, and to determine the equality of voltage by reference to a Kelvin electrostatic voltmeter. The method can scarcely conduce to very accurate results. In meter testing a number of meters are connected in series on the meter racks; current for their field coils is taken either from a few cells of storage battery or from a step-down transformer. Potential is taken from the supply mains. A Kelvin standard watt balance is connected in the circuit and the watts supplied are kept constant by manipulating a carbon plate rheostat in the field circuit. Meters to be tested are first screwed to boards and these boards are attached by clamping screws to racks. The arrangement ought to give good results.

The Electrical Standardizing, Testing and Training Institution, in Faraday House, maintains a laboratory for making electrical tests for the public on a commercial basis. The work which has been done in this laboratory, now for a number of years, is of the same nature as that which the Electrical Testing Laboratories are doing. This concern has been a commercial success. Its material equipment, however, is rather meagre, and in no respect markedly different from those of other English laboratories. It has a teaching department in which a considerable number of young men are being instructed in electrotechnics.

Among English laboratories intended primarily for teaching electrical science, three which the writer visited are worthy of special note. These are the Laboratory of the Central Technical College (Professor Ayrton's laboratory), Pender Laboratory of University College (Professor Fleming's laboratory) and the electrical engineering laboratory of Cambridge University (Professor Ewing's laboratory). All of these laboratories are well equipped for the purpose and do not suffer by comparison with similar laboratories on this side of the water.

Passing from London to Paris, we note in the latter place two extensive and well-equipped testing laboratories. The first of these is the laboratory of the Conservatoire des Arts et des Metiers. This laboratory is splendidly housed, but is as yet only incompletely equipped. Its chief work is mechanical testing, although electrical and photometrical testing also find a place therein.

The other is the Laboratoire Central d'Electricité. This laboratory was founded in 1888, under the auspices of the Société Internationale des Electriciens, as a result of an agreement between the Society and the French Government, by virtue of which the sum of 300,000 francs, which had reverted to the State as profits of the International Exposition of Electricity, in 1881, was, by the original agreement made between the promoters of the exposition and the French Government, applicable to a work of public interest. At this time 30,000 francs were devoted to the first installation, while the State guaranteed an income of 11,000 francs to the laboratory. A few years later, the City of Paris ceded to the International Society for a period of sixty years, a site for a laboratory.

A sum of 200,000 francs was raised, partly by subscription by the manufacturing interests represented in the International Society, suitable buildings were erected and the work of the laboratory was largely increased.

The control of the operations of the laboratory is carried out by functionaries of the general director of Posts and Telegraphs, who is also authorized to direct the financial matters, regulate the charges imposed and the expenses of the laboratory. The actual administration of the laboratory is carried on by a commission composed of the bureau of the society, the past presidents of the society, the president of the Syndicate of Electrical Industries and a delegate of the Municipal Council of the City of Paris. The personnel of the laboratory are under the orders of the director, but the appointments of heads of departments and assistants are made by the commission, who also must authorize any expenditures larger than 200 francs.

The work of this laboratory comprises electrical tests and standardizations of practically all kinds. Tests may also be carried on outside the laboratory by members of its force. The rates charged for the work of the laboratory are published, are uniform to all parties, the government included, and are quite low. The equipment of the laboratory itself, while not very large, is good and is well arranged.

This must be considered in connection with another institution also organized under the auspices of the Société International des Electriciens, housed under the same roof as the laboratory and placed under the same director. This is the higher school of electricity. The laboratory equipment of the school is excellent and is at the disposal of the Central Laboratory for carrying out its tests. A large number of dynamos and measuring instruments are available, and this, like all other laboratories, both in England and on the Continent, is liberally equipped with storage batteries. Both the laboratory and the school are institutions which are doing excellent service for electrical science in France.

Belgium possesses a very noteworthy laboratory in the Montefiore Institute of the University of Liège. This laboratory is installed in a splendidly constructed building and is arranged with most admirable regard for all details. Its equipment is very large and its methods are modern. The appearance of perfect order and neatness which prevails in this laboratory makes it impress one as being a drawing room laboratory. There is no doubt, however, as to the quantity and quality of work which is carried out there. The director of the laboratory is Professor Eric Gérard.

The greatest testing laboratory in the world is the Physikalisch-technische Reichsanstalt, in Charlottenburg, an annexed district of Berlin. This is an entirely governmental institution. It is under the immediate supervision of a president, Professor Kohlrausch, who, in this capacity, is the successor of von Helmholtz. The institution is divided into two sections, designated as Section I and Section II. Section I is the physical section, where problems and investigations coming under the domain of pure physics are handled. Section II, which is under the immediate supervision of Professor Hagen, takes up the technical investigation and tests.

The main buildings of the institution are three in number. One of these serves for Section I; another for

the feeble-current work of Section II, and the third as a power house and heavy-current laboratory of Section II. Under heavy-current testing is included the great majority of electrotechnical tests, including tests of dynamos, motors, transformers, meters, etc. The magnificent character of the buildings, which evinces the large amount of money which has been lavished on their construction, gives testimony to the high value which the Germans place upon work of testing and investigation. The buildings are of stone, handsome architecturally, massive and very spacious. No one seems to be in the slightest degree cramped for room. The personnel of the Reichsanstalt includes a number of the most noteworthy German men of science. The presidency of the Reichsanstalt is by common consent the highest position to which the German physcist can aspire, and is awarded to the most eminent man in that branch of science.

The work of the Reichsanstalt includes the making of tests, the carrying out of investigations both for private individuals and industrial concerns and the public generally. The annual expenses, amounting to about 3,500,000 marks, are covered by the fees received in payment for tests and by a governmental appropriation. The fees amount to about 15 per cent. of the total expenditure.

Many noteworthy investigations of the highest importance to both electrical science and electrotechnics have been carried out in these laboratories. The benefit which has been derived from the Reichsanstalt by the electrical and other industries in Germany has been very great. The extent of the work is such that it has been possible to subdivide it into its various proper departments, putting at the head of each a thoroughly equipped specialist, who is provided with the necessary assistants. Thus, in the magnetic laboratory, under Dr. Gumlich, are carried out tests of the magnet properties of samples of iron, such as actually enter into electrical machines. Not only this, but this department also calibrates apparatus designed for carrying out commercial tests of the magnetic properties of iron and has worked out a systematized method by which such tests can be carried on without the intervention of the errors which commonly enter into magnetic tests.

The photometric department, under Professor Brodhun, in addition to tests of various sources of light, has made careful study of the question of primary standards of light.

The equipment of the Reichsanstalt, both as to apparatus and sources of electrical current, is very complete. Its general usefulness is, however, considerably hampered by the fact that its work is carried on in a leisurely manner, likely to be a characteristic of a governmental institution, while its methods are so rigid that it is difficult to get anything done except in the prescribed way and at the prescribed time.

In various important cities of the German Empire there are testing laboratories which determine the accuracy of instruments and meters concerned in the public supply of electric current. These laboratories are under the general direction of the Reichsanstalt, and derive their standards and their methods from it.

The most noteworthy of these is the City Test Office of Munich. This laboratory is housed in a handsome stone building adjoining the municipal electric powei house, and is, in its way, quite as remarkable a laboratory as the Reichsanstalt. It is no less splendidly arranged and equipped. The work of the laboratory includes the testing of meters, cables, lamps and all other appurtenances of a system for the generation of a supply of electricity. Each department has a spacious room of its own, quite fine enough to suit the most fastidious taste. The apparatus available is the best which Germany can produce. But be it noted here in passing that Germany knows as little about apparatus produced in the rest of the world as England does. There may be such things as Kelvin balances in Germany, but, if there are, the writer is unaware of their location.

Among the industrial testing rooms which it was the writer's privilege to visit were those of the Aron Meter Company and of the meter department of the Union Elektricitäts Gesellschaft. The testing of the Aron meter is carried out by connecting them in series with standard meters built on the same principle. These standard meters have very fine clocks, with long pendulums, to which the potential coils are connected. This method of testing should lead to very accurate results. The testing arrangements of the Union Company do not differ markedly from those employed on this side of the water. Their equipment includes the original of the mechanical phase-shifting, alternator set which has been mentioned above, the originator and patentee of this device being Dr. Stern, engineer in charge of this department.

Very prominent among the electrical laboratories intended for teaching purposes is that at the Technical High School, in Charlottenburg. The arrangement and equipment of this laboratory are quite in keeping with the magnificence of the building in which it is housed. The director of this laboratory is Professor Wedding, who is particularly well known for the numerous photometric researches and tests which he has carried out. Their equipment for the particular purpose of photometric testing is not very great in extent, but has sufficed for accomplishing a great deal of good work.

The great electrotechnical laboratory of the Polytechnicum, in Zurich, is even greater in extent than that at Charlottenburg, though it is, perhaps, in many respects, less modern.

A very notable physical laboratory has been erected and is in course of completion in Leipzig. About one and a half million marks are being expended on this laboratory, which liberal appropriation should make it the finest and most extensive for pure physics in the world. Although intended for theoretical and experimental physics, its output is almost certain to include a great deal which will be of value in electrotechnical industries.

Comparisons are not necessarily always odious. They are usually instructive and are quite as likely to conduce to humility as to self aggrandizement. We may venture, therefore, to draw comparisons between the material and methods in European laboratories and those with which we are familiar at home. We note first that we have not yet any laboratory which can be compared with the Reichsanstalt. The National Bureau of Standards has made a very good start in this direction and, from present indications, it is not likely to be many years before, in material appointments, it equals or surpasses the model on which it is based. It is in the fortunate position of being able to select without prejudice all that is best from among the apparatus and the methods which are available.

The Electrical Testing Laboratories is in similar position in its particular field. Its equipment includes the best apparatus which is available, irrespective of its origin. As an example we may note that, in the magnetic testing of iron, if the sample is presented in the form of a ring, it is tested according to Rowland or Ewing; if in the form of a bar, it can be tested on a permeameter made in Berlin, and the indications of this apparatus may be checked by retesting on an entirely different form of permeameter made in Paris.

In none of the foreign laboratories is there an equipment for all the various kinds of photometric work

which equals in completeness or in excellence that which the Electric Testing Laboratory has installed. The one most nearly approaching this is the equipment at Laboratoire Central, in which a great many of the most important photometric measurements of recent years have been carried out. The methods of carrying out tests in foreign laboratories are, in general, less expeditious than in this country. One important reason for this is that our laboratories are better supplied with Weston direct-reading instruments and that we make more extensive and intelligent use of them. When this is done, the greater speed with which we are able to turn out work does not involve any lessening of accuracy of results, but simply diminishes the amount of painstaking care which must be taken to obtain these results.

It appears that great electric lighting companies in this country, which include, in general, the members of this association, appreciate the advantages which accrue to them from tests and investigations of the material with which they have to do. If, however, we leave out of account these companies, there is probably less appreciation of these things in this country than there is abroad. As an evidence of this statement, it need only be pointed out that the laboratories which have been mentioned have, in nearly every case, been established earlier than any public testing laboratory in this country. That the state of affairs is changing in this respect is evident by the throwing open to the public of the Electrical Testing Laboratories and by the establishment of a National Bureau of Standards. In the meantime, it is the general impression abroad, especially in Germany, that Americans are very easily satisfied, that they care very little for accuracy or refinement in method of measurement, and that the published results of tests made in this country are of comparatively little value. How erroneous this impression is you all know. It has been a rather general impression in this country that the Germans are the exponents in all that is painstaking and accurate. It is the writer's impression that this generalization may at times lead to conclusions quite as erroneous as the former one. Fortunately, no one country has a monopoly of the material resources or of the skill required in accurate testing. While we ought not to feel too well satisfied with our position in this regard, we may, nevertheless, be assured that, if we have much to learn from others in these matters, the others also have some things to learn from us.

Personal

Among the members of the British Institution of Electrical Engineers at present visiting this country are Col. R. E. Crompton, of the well-known British electrical firm of Crompton & Co., Ltd., London, and Prof. John Perry, late president of the Institution and occupying the chair of mechanics and mathematics at the Royal College of Science, London. Col. Crompton, when he can be inveigled into talking of his part in the recent Boer war in South Africa, is full of interesting reminiscences which concern themselves mainly with the important services of engineers in modern warfare. Gen. De Wet, he says, at one time captured half a dozen of his engineers whom he declined to exchange, even at big odds, so as to deprive the British of their services.

Prof. Perry is accompanied by Miss Perry, who is generally credited with being almost as highly accomplished in things mathematical as her uncle, and this is saying much when it is borne in mind that Prof. Perry has been the leading spirit of Great Britain in the reform of teaching mathematics and has evolved a new system, already used in many technical colleges, from which the older methods have been completely ousted. Even the most orthodox of Cambridge mathematicians have commended the new Perry method, but only for students intending to become engineers, whereas Prof. Perry proposes it as the best system for all students, even for those who intend to proceed to the most advanced kind of pure mathematics.

COL. R. E. CROMPTON

PROFESSOR JOHN PERRY

Gen. H. H. C. Dunwoody, U. S. A., retired, vice-president of the American De Forest Wireless Telegraph Company, is in charge of the company's Washington office, and will be the personal representative of the company in its future dealings with the Government. General Dunwoody was retired from the army only a few weeks ago, after a career covering a period of nearly forty years. He was graduated from West Point in 1866 and served as captain of artillery prior to his promotion, as the result of a competitive examination, to the position of major in the signal corps. In the Spanish war the volunteer signal corps was organized under his direction and was equipped and placed in service within thirty days after authorized by act of Congress. General Dunwoody was made colonel in this corps, and the thoroughness with which the corps was organized was officially recognized. General Dunwoody was one of the first army officers to take up the study of wireless telegraphy.

GENERAL H. H. C. DUNWOODY

O. H. Ensign, of Los Angeles, has resigned his position as electrical and mechancal engineer of the Edison Electric Company, of that city, to be-

come connected with the United States Reclamation Service in charge of hydraulic power development and electrical work. His headquarters will be in Los Angeles, and he will report directly to Chief Engineer Newell.

Professor Clarence Feltman, head of the department of electrical engineering at the University of Darmstadt, Germany, is in America investigating the methods for the teaching of electrical engineering.

Dr. Willis R. Whitney, professor of theoretical chemistry at the Massachusetts Institute of Technology, has resigned, and will take charge of the research laboratories of the General Electric Company at Schenectady, N. Y.

The General Incandescent Arc Light Company, of New York City, has appointed E. L. Nash district manager for its branch office in Philadelphia. Mr. Nash has been connected with the Jandus Electric Company in the capacity of Eastern sales manager for the last nine years.

Wilfred J. Thompson, who was formerly with the Westinghouse Machine Company, has gone to Manchester, England, where he will engage in turbine work for the British Westinghouse Electric & Manufacturing Company.

Carl Hambuechen, well known to the electrochemical fraternity as Prof. Burgess' co-worker in his experiments with electrolytic iron at the University of Wisconsin, is now connected with the Pittsburg Reduction Company, at East St. Louis, Ill.

Charles D. Knight, who has been for many years well known throughout the electrical industry, has resigned his position with the National Electric Company, of Milwaukee, and joined the engineering staff of the Cutler-Hammer Company, of that city.

H. C. Spaulding, assistant sales manager of the Triumph Electric Company, Cincinnati, Ohio, has been placed in charge of a recently opened branch office at Baltimore, Md.

At the recent convention of the Association of Edison Illuminating Companies, held at Newcastle, N. H., the following officers and executive committee were elected:—President, Joseph B. McCall, Philadelphia, Pa.; vice-president, D. L. Huntington, Spokane, Wash.; treasurer, Alex Dow, Detroit, Mich.; secretary, E. A. Leslie, Brooklyn, N. Y.; assistant secretary, H. C. Lucas, Philadelphia, Pa.

JOSEPH B. MCCALL, THE NEW PRESIDENT OF THE ASSOCIATION OF EDISON ILLUMINATING COMPANIES

Executive committee, Joseph B. McCall, chairman; Samuel Insull, Chicago, Ill.; John W. Lieb, Jr., New York; C. A. Brine, Atlanta, Ga.; Alex. Dow (ex-officio), Detroit, Mich.; E. A. Leslie (ex-officio), Brooklyn, N. Y.; Louis A. Ferguson, Chicago, Ill.; Charles L. Edgar, Boston, Mass.; D. L. Huntington (ex-officio), Spokane, Wash.

William C. Candee, assistant secretary of the Okonite Company, New York, was dangerously injured in a trolley accident in Brooklyn, on August 18. A trolley car in which he was riding collided with an ice wagon, and the end of the pole struck him in the forehead, fracturing his skull, crushing his nose and driving fragments of his eye-glasses into his right eye. Mr. Candee was removed to Seney Hospital and is now on the road to complete recovery.

Henry J. Eberhardt, who was for many years with Gould & Eberhardt, of Newark, N. J., and Elmer G. Eberhardt, who was also with the same company for several years, and Frank E. Eberhardt, another brother, are now associated in business as Eberhardt Brothers Machine Company. The new firm will specialize in the manufacture of gearing and gear cutting machinery, at Newark, N. J.

Paul Doty, for several years general manager of the Denver Gas & Electric Company, has been appointed to the same position with the St. Paul Gas Light Company, which controls the St. Paul Edison Electric Light & Power Company.

CHARLES L. EDGAR

Charles L. Edgar, president of the Edison Electric Illuminating Company, of Boston, was recently presented with a fine bronze bust of Edison by his employees, associates and friends. The bust stands on a pedestal, the total height being 6 feet 3 inches.

Calvin Winsor Rice, consulting electrical engineer for the General Electric Company, in New York City, was married at Winchester, Mass., on August 6, to Miss Ellen Moseley Weibezahn, daughter of Mr. and Mrs. W. E. Weibezahn, of that town.

Joseph Baker, of Boston, has joined the publication bureau of the General Electric Company, under Martin P. Rice, of Schenectady, N. Y.

Carl Hering, of Philadelphia, has been appointed a member of the Jury of Awards for the Electrical Exhibit of the St. Louis Exposition. Mr. Hering's many years of experience in electrical lines particularly qualify him for this service.

Prof. W. C. Unwin, of London, is here to attend the International Engineering Congress to be held at St. Louis, from October 3 to October 8, under the auspices of the American Society of Civil Engineers. Prof. Unwin is down on the programme for a paper on "Engineering Education."

F. V. Kershaw, for several years connected with the engineering and manufacturing departments of the Crocker-Wheeler Company, of Ampere, N. J., has resigned and has planned for a period of rest before engaging in any other business. Mr. Kershaw has had entire charge of the estimating and installation work of the company.

Trade News

The Abner Doble Company, engineers, of San Francisco, have secured the Pacific Coast agency for the Kohler system for the electric operation and speed control of newspaper printing presses, and during the last week they have closed a contract with the Oregonian Publishing Company, at Portland, Ore., for a 50-H. P. Crocker-Wheeler motor, with the Kohler system control. The company also recently secured the Pacific Coast agency for the Electric Controller and Supply Company, Cleveland, Ohio, manufacturers of hoists and elevator controllers, crane fittings and lifting magnets.

A direct motor-drive for planers is a feature of the St. Louis Exposition exhibit of the Electric Controller & Supply Company, of Cleveland, Ohio. This drive brings the planer to the same high efficiency as the motor-driven lathe. The motor is geared direct to the cross shaft, and instant change and control of speed is obtainable without changing gears or stopping the planer. A new system of control, specially adapted to mill-table motors, is also shown in operation, and several distinct lines of crane controllers as well. These controllers are specially designed to withstand the rough handling which is usually the lot of such apparatus in mills and factories. They are all built with the resistance self-contained. All parts are easy of access for inspection, and the wearing parts are made renewable, thus cutting the repair expense to a minimum. Further exhibits by the same company are a line of knife switches, cast grid resistance banks, magnetic friction and stop brakes and crane fittings, and a working exhibit of the Clark lifting magnet. This magnet is suspended on a Brown Hoisting Machinery Company tramway hoist, and will be of special interest to those who have billets, slabs or plates to handle. The exhibit is in charge of an experienced electrical engineer, who will be pleased to give information to those interested.

For the purpose of carrying out extension projects that have been in contemplation for some time, the Westinghouse Electric & Manufacturing Company have offered to stockholders the remaining 50,000 shares of the treasury stock at $80 per $50 share. Holders on record on August 8 will be entitled to subscribe to the additional $2,500,000 at the rate of one share for every nine shares then held, the subscription lists to close August 15. The balance sheet of the Westinghouse Company which was issued on August 2, showed a large increase in surplus. The surplus on that date was $11,882,105, as against $8,812,399 on June 30 of last year.

The J. G. Brill Company, of Philadelphia, have received an order for 150 new trolley cars from the Metropolitan Street Railway Company, of New York, and another for the same number of cars from the United Railways and Electric Company, of Baltimore.

The Perkins Machine Company, manufacturers of stamping and drawing presses and special machinery, have just installed a 30,000-pound capacity electric traveling crane, of the Pawling & Harnischfeger make, in their new plant at Warren, Mass.

The Northern Electrical Manufacturing Company, of Madison, Wis., recently sold to Greenlee Brothers, of Chicago, Ill., a 200-K. W. generator. Another sale has been made to the Water Works Company of Fond du Lac, Wis., of a 90-H. P. vertical motor for pumping service. This motor is to be used for driving a propeller type of deep-well pump.

The Denver Engineering Works Company, of Denver, Col., announce that, in order to expedite the handling of their constantly increasing business, they have appointed Lyman P. Hammond as sales manager. Mr. Hammond has resigned his position as manager of the Denver branch of the Crocker-Wheeler Company, and will take charge of all work relating to the sale of The Denver Engineering Works Company's products after September 15. He will be located at the city office of the company in the McPhee Building, Denver. Mr. Hammond has had a broad experience in the manufacturing industry, and has made a good record in the sale of Crocker-Wheeler apparatus.

Russia's only building at the St. Louis Exposition is a pavilion in the Palace of Transportation erected by the Westinghouse Company, Ltd., of St. Petersburg, as a feature of the Westinghouse brake exhibits. In the Palace of Machinery the same company has furnished a small Russian kiosk at the head of the row of national booths erected by the different Westinghouse companies of Europe and America, and at both places Russian tea, brewed in curious old samovars, and suchari, a sweet native biscuit, are served to visitors of the company by Russian girls wearing richly embroidered boyarin costumes. The pavilion in the Palace of Transportation covers a space 20 by 25 feet, and is 25 feet high. It was constructed by peasant builders in the Possade Ser-

giewo, near Moscow, after designs by the native architect, Baranowsky, who has done much important work in St. Petersburg. The style of construction is quite primitive, the exterior being that of a forest log cabin. The logs are neatly hewn, however, and notched together so closely that no open joints remain to be plastered, as in American huts. The rafters of the high roof, also, are mortised into the plate, and no nails whatever are necessary in the construction—the entire building having been shipped to this country in boxes. The fantastic taste of the peasants is indicated in the curiously cut eaves, gables and cornices, which are elaborately ornamented and painted in the gayest colors. The material used throughout is a white pine from the forests around Moscow, the carved furniture being very effectively stained. All the interior decoration was designed by Durnowo, whose work has been highly appreciated in the Russian buildings at many international expositions. The ornamental pottery and bric-a-brac were collected from various museums to show characteristic Russian art of various periods, and the hangings in the pavilion and in the kiosk, made of wool by peasants, follow out the general design of the interior, as is customary in Russian decorating. One entire wall is covered by a hand-painted map of the world, by Ingenier Prochanof, with Russian text, the only large Russian map on the grounds, and Russian visitors are further attracted by files of newspapers and periodicals. U. Grant Smith, brother of the general manager of the Russian Westinghouse Company, is in general charge of the Russian exhibit, and Gospodin M. N. Konshin, of St. Petersburg, receives and welcomes his countrymen at the fair.

New Catalogues

The Electrical Appliance Company, of Cincinnati, Ohio, are sending out a folder describing and explaining the use of the Churcher alternating-current rectifier and rectifying interrupter.

"The Book of the Four Powers" is the title of a new publication sent out by the Allis-Chalmers Company, of Chicago, treating of the application of steam, gas, water and electricity to various uses through the medium of the company's engines, turbines, motors and generators. The pamphlet contains many illustrations of plants of the "four powers" installed by the company, with descriptions of the main features of each class of machines. A considerable part of the pamphlet is devoted to mining, the many machines made by the Allis-Chalmers Company for use in this field being illustrated and described. Saw-mill machinery and timber-preserving plants are also dealt with briefly.

The Sargent gas engine, built by the Wellman-Seaver-Morgan Company, of Cleveland, Ohio, is illustrated and described in a new catalogue sent out by that company. The main features of the engine are described and its advantages are fully set forth.

The Abner Doble Company, engineers, of San Francisco, are sending out a pamphlet containing particulars of a test of the Doble needle regulating nozzle by H. C. Crowell and G. C. D. Lenth, of the Massachusetts Institute of Technology. The characteristics of the nozzle and the jet and the efficiency of the jet are discussed, and illustrations of the jet are given, with velocity curves, and tables of pressures and velocities.

The advantages of gas for power and as fuel are discussed in a pamphlet sent out by R. D. Wood & Co., of Philadelphia. The pamphlet contains illustrations and descriptions of gas-producer plants for power-plant use, and also illustrations of cast-iron pipe, valve-posts and fire hydrants, high-duty pumping engines, hydraulic riveters, centrifugal pumps and gas holders.

A booklet has been issued by the Nernst Lamp Company, of Pittsburg, Pa., illustrating and describing the municipal lighting system at Berwyn, Ill. The streets of Berwyn are lighted entirely by Nernst lamps. This installation ought to prove of value in determining the utility of the Nernst lamp as a street lighting medium for towns and in placing it in a position between the inefficient incandescent system and the up-to-date arc system.

Centrifugal pumps are the subject of a new catalogue issued by the Lawrence Machine Company, of Lawrence, Mass. Details of construction are briefly described and a diagram is given showing the most approved method of erecting the pumps to secure the best results. Illustrations of the many types of pumps, single and multi-stage, direct-connected and belted, are given in the catalogue, together with tables of capacity for each type. Several illustrations are also given of the engines built by the company for direct connection or belt drive. A table of discharge capacities for various diameters of pipe and velocities, and a table of friction heads for 100-foot lengths of various pipe diameters are also given.

The Warner & Swasey Company, of Cleveland, Ohio, have sent out a new machine tool catalogue. The booklet illustrates and describes turret lathes, turret screw machines, valve milling machines, automatic boring and tapping machines, double-head key lathes, cock grinders, cutting-off machines, vertical turret machines and horizontal boring machines. The catalogue also shows the auxiliary fixtures used on these machines, as well as the friction counter-shafts and the turret parts.

Ambursen & Sayles, engineers, of Watertown, N. Y., are sending out a pamphlet relating to concrete-steel gravity dams. The first part of the pamphlet treats of concrete-steel dams in general, and the latter part treats of the Ambursen concrete-steel dam in particular. Diagrams are given showing the construction of these dams under various conditions, together with illustrations of work done with this method of building. A bulletin has also been issued illustrating and describing the building of the first Ambursen concrete-steel dam at Theresa, N. Y.

Execution by Electricity

IN discussing the question "Are we ever entirely sure that the person in the electric chair is killed by the electric fluid," a correspondent of "The Medical Record" says:—

"There are those who think that the so-called post-mortem is in most cases ante-mortem, and that the knife, not the electric current, does the work.

"A prominent physician in New York City, who has given much time to the study of electrical therapeutics, says that he has long been of the opinion that a considerable number of those who have been sent to the chair could have been resuscitated after they had been pronounced dead and up to the time of the so-called autopsy.

"Chloroform," says this correspondent, "might not be a bad substitute for electricity. Prussic acid is one of a number of chemical agents worth considering in this connection. There are narcotics that might be used. The criminal could be made to sink through a quiet sleep into that deeper sleep from which he will not revive. Should he refuse the draught, a hypodermic injection would certainly cover the case.

"It is contended by the advocates of electrocution that death by the current is painless. There is abundant reason for believing the contrary to be the case. A number of persons who have received shocks of high voltage, from which they have recovered, tes-

THE ELECTRIC CHAIR IN THE STATE PRISON AT OSSINING, NEW YORK

tify to the great distress they endured. The pain is described as having been intense."

The following paragraph is taken from a communication addressed to "The American Inventor," by Mr. A. B. Brooks, an electrician of some celebrity. He accidentally got hold of a telephone wire grounded. He says:—"The duration of the shock could not have been more than a couple of seconds. A man riding by on a wheel going at a good speed had only time to pass about 30 yards beyond me when the operator got through talking and opened the switch, yet I could see every spoke in the bicycle, and it barely seemed to me to be turning. I could feel every reversal of the current, and these reversals occur at the rate of sixty complete cycles per second."

"It is this intense activity of the brain to electrical impressions that makes an instant of electrical shock seem hours to the sufferer. Of course it is impossible to know what a man dying of strangulation suffers, but I will positively affirm that any man who has ever had a severe shock will prefer anything to another. The fact that my own case was not fatal does not alter my opinion that death by the electric chair is most painful. The sensations of pain and the elongation of the sense of consciousness of time seem to increase in direct proportion to the violence of the shock. If I suffered what seemed to me hours with a current which did not kill, what may not a man suffer with a stronger shock between the time of its first application and his final loss of consciousness."

The Michigan State Telephone Company, of Detroit, has been asked to establish telephone toll boxes along the toll roads leading out of Detroit.

Underwriters' Rules for Car Wiring and Equipment

A CONFERENCE committee, consisting of a committee appointed by the American Street Railway Association and a sub-committee of the Underwriters' National Electric Association, has formulated a set of rules to be observed in car wiring. The more important rules follow:—

PROTECTION OF CAR-BODY, ETC.

1. Under side of car bodies to be protected by approved fire-resisting insulating material, not less than ⅛ in. in thickness, or by sheet iron or steel, not less than .04 in. in thickness, as specified in Sections 2, 3 and 4. This protection to be provided over all electrical apparatus, such as motors with a capacity of over 75 H. P. each, resistances, contactors, lightning arresters, air brake motors, etc., and also where wires are run, except that protection may be omitted over wires designed to carry 25 amperes or less if they are encased in metal conduit.

2. At motors of over 75 H. P. each, fire-resisting material or sheet iron or steel to extend not less than 8 in. beyond all edges of openings in motors, and not less than 6 in. beyond motor leads on all sides.

3. Over resistances, contactors and lightning arresters, and other electrical apparatus, excepting when amply protected by their casing, fire-resisting material or sheet iron or steel to extend not less than 8 in. beyond all edges of the devices.

4. Over conductors, not encased in conduit, and conductors in conduit when designed to carry over 25 amperes, unless the conduit is so supported as to give not less than ½ in. clear air space between the conduit and the car, fire-resisting material or sheet iron or steel to extend at least 6 in. beyond conductors on either side.

Note.—The fire-resisting insulating material or sheet iron or steel may be omitted over cables made up of flameproof braided outer covering when surrounded by ⅛ in. flameproof covering, as called for by Section 4 under motor circuits.

5. In all cases fireproof material or sheet iron or steel to have joints well fitted, to be securely fastened to the sills, floor timbers and cross braces, and to have the whole surface treated with a waterproof paint.

6. Cut-out and switch cabinets to be substantially made of hard wood. The entire inside of cabinet to be lined with not less than ⅛ in. fire-resisting insulating material which shall be securely fastened to the woodwork, and after the fire-resisting material is in place the inside of the cabinet shall be treated with a waterproof paint.

MAIN MOTOR CIRCUITS AND DEVICES.

1. Conductors connecting between trolley stand and main cut-out circuit breakers in hood, to enter car through approved bushings, or to be protected where wires enter car to prevent ingress of moisture.

2. Conductors connecting between third-rail shoes on same truck, to be supported in an approved fire-resisting insulating molding, or in approved iron conduit supported by soft rubber or other approved insulated cleats.

3. Conductors on the under side of the car, except as noted in No. 4, to be supported in accordance with one of the following:—

a. To be run in approved metal conduit, junction boxes being provided where branches in conduit are made, and outlet boxes where conductors leave conduit.

b. To be run in approved fire-resisting insulating molding.

c. To be supported by insulating cleats, the supports being not over 12 in. apart.

4. Conductors, with flameproof braided outer covering, connecting between controllers at either end of car, or controller and contractors, may be run as a cable, provided the cable where exposed to the weather is encased in a canvas hose or canvas tape, thoroughly taped or sewed at ends and where taps from the cable are made, and the hose or tape enters the controllers.

Conductors with or without flameproof braided outer covering connecting between controllers at either end of the car, or, controller and contactors may be run as a cable, provided the cable throughout its entire length is surrounded by ⅛ in. flameproof covering, thoroughly taped or sewed at ends, or where taps from cable are made and the flameproof covering enters the controllers.

Cables, where run below floor of car, may be supported by approved insulating straps or cleats. Where run above floor of car, to be in a metal conduit or wooden box painted on the inside with not less than two coats of flameproof paint, and where this box is so placed that it is exposed to water, as by washing of the car floor, attention should be given to making the box reasonably waterproof.

Canvas hose or tape, or flameproof material surrounding cables after conductors are in same, to have not less than two coats of waterproof insulating material.

5. Motors to be so drilled that, on double-truck cars, connecting cables can leave motor on side nearest to king bolt.

6. Resistances to be so located that there will be at least 6 in. air space between resistances proper and fire-resisting material of the car. To be mounted on iron supports, being insulated by non-combustible bushings or washers, or, the iron supports shall have at least 2 in. of insulating surface between them and the metal work of car; or, the resistances may be mounted on hard wood bars, supported by iron stirrups, which shall have not less than 2 in. of insulating surface between foot of resistance and metal stirrup, the entire surface of the bar being covered with at least ⅛ in. fire-resisting insulating material.

The insulation of the conductor, for about 6 in. from terminal of the resistance, should be replaced, if any insulation is necessary, by a porcelain bushing or asbestos sleeve.

7. Controllers to be raised above platform of car by a not less than 1 in. hard wood block, the block being fitted and painted to prevent moisture working in between it and the platform.

Protection Against Lightning

IN order to more thoroughly understand the methods of protection against lightning, and because of the frequency of fires caused by lightning, a committee was appointed by the National Fire Protection Association, of which Inspector W. S. Lemmon, of the German-American Insurance Company, of New York, was made chairman, to investigate such fires and submit specifications for their prevention.

The committee, according to "Insurance Engineering," has presented a preliminary report, and a part of this is an interesting table showing the following results:—From 1898 to 1902 there was a total of 357,346 fires investigated. Of these 15,755 were caused by lightning. Of a total loss by fire of $780,000,000, the fires due to lightning caused a loss of $21,767,185.

These figures indicate an average number of lightning fires per year of 3151, as compared with an average number of 71,469 from all causes. The figures show an average total loss per year from lightning fires of $4,353,437, as against an average of $156,000,000 from all causes. Of the buildings affected by fires caused by lightning included in this tabulation, 3842 were dwellings (an average of 768 per year); 9375 were barns (an average of 1785 per year); 328 were

churches (an average of 66 per year), and 38 were ice-houses (an average of 8 yer year).

The committee remarks that no generally accepted theory of thunderstorms has yet been formed, although, in a number of special cases, a realization of the conditions existing at the time has been arrived at. To what extent forests and trees act preventively is no more definitely known than the degree of protection afforded by lightning rods, although it seems to be established that trees surrounding a building, if not too near, are a source of protection; but if too near, prove to be a menace.

The lightning rod conference in London, 1882, gave the following order as to the susceptibility of different kinds of trees to lightning:—oaks, 100; elms, 77; pines, 33; firs, 10; fir trees in general, 27, and beeches, 2. It is well established that trees standing in temporarily or permanently moist soil are more likely to be struck than those in sandy or dry soil.

It has been proved that lightning conductors, properly installed, are a protection, and notwithstanding that one is providing against an unknown quantity of current, it is believed that there is a limitation which, if provided for by sufficient metallic surface area properly arranged, may absorb and dissipate any charge likely to occur. At the same time, the protection afforded by a conductor will depend upon the relative positions of the electric discharge and the object it meets in its course. The more any object projects above the general level, the nearer to the cloud and the less the resistance offered to the discharge. High objects are therefore more frequently struck; hence the need for more careful protection.

A lightning conductor fulfils two functions: it facilitates the discharge of the electricity to the earth, carrying it off harmlessly, and it tends to prevent disruptive discharge by neutralizing the conditions which determine such discharge in the vicinity of the conductor.

A number of specifications are included in this report for the protection of buildings against lightning. Protection against lightning is advisable on country buildings, on isolated buildings, and on all buildings, wherever located, having elevated features, such as tall chimneys, steeples, high-peaked or gabled roofs and flag-poles. One rod with proper area and earth terminal is recommended per unit of roof area, as follows:—

Pitched roofs of metal, one each 2000 square feet of area; pitched roofs other than metal, one each 5000 square feet of area; flat roofs other than metal, one each 2500 square feet of area; flat roofs of metal, one each 5000 square feet of area. Where trees stand so close to a building that branches overhang or approach very close to the roof, a conductor with proper earth terminals should extend along the trunk of each tree to near the highest branch top, fastened by a band around the branch or trunk, and equipped with a cluster of points. If extreme protection is desired, wires should be strung from tree to tree across the roof of the building, and all connected together, the ends being separately grounded. In either case the buildings should also be equipped.

But one kind of material should be used in the same system. The conductors should be in sheet or tape form, of either copper weighing not less than 6 ounces per foot, or of iron weighing not less than 2¼ pounds per foot. The upper point should be cone-shaped, and the height of the cone should be equal to the radius of the base.

Air terminals should be of copper rod not less than ⅝-inch in diameter. Terminals should extend not less than 3 feet above flat or peaked roofs or chimneys, and should be firmly secured in an upright position. They should be run as straight as possible, avoiding all turns of a radius less than 1 foot. The conductor should never be insulated, but fastened securely to the surface to be protected by clamps of the same kind of metal. Conductors should never be run through iron pipes. The best ground consists of a copper plate not less than 2 x 2 feet by 1-16-inch, buried in permanently damp earth below the frost line, and not less than 4 feet below the surface, with 3 inches of crushed coke or charcoal underneath, and the same material above to within 6 inches of the surface of the ground.

Electrolysis of Water Mains in Boston

ELECTROLYSIS of water mains in the Boston Metropolitan District continued at a serious rate during the year 1903, According to "The Engineering Record," the report recently issued by the Metropolitan Water and Sewerage Board shows that on 90 linear feet of 48-inch pipe in Cambridge, uncovered for examination, 525 pittings were located, varying from 1-16 to ⅝-inch in depth.

Portions of two lines of 36-inch cast iron pipes crossing under the Charles River were examined by a diver, and eleven pittings from 2 to 6 inches in diameter and from ⅜ to ¾ inch in depth were found. These pipes in the river are being destroyed very rapidly. At several other river crossings the conditions have been found to be favorable for electrolytic action, and at several points damage has been discovered. In the city of Chelsea an examination of a 24-inch cast iron pipe line disclosed 250 pittings, from 1-16 to 9-16 inch in depth, on 280 square feet of pipe surface.

In Lynn at one point 387 pittings, from 1-32 to 7-16 inch in depth, were found on 175 square feet of the surface of a 12-inch pipe line, and at another place 200 pittings on an area of 44 square feet; the deepest pittings were .45 inch in depth, leaving but .24 inch of the original thickness of the pipe. It has become necessary to replace some of these pipes during the current season. In order to prevent the flow of quite a large amount of electricity from the Metropolitan pipes to the pipes in the city of Cambridge, at a connection, an insulating joint, made of a rubber gasket ½ inch in thickness placed between two flanges, was used.

A Government Telephone Plant

AS a result of a cabinet meeting held recently, Secretary Morton, of the Navy Department, will immediately commence an investigation as to the advisability of the Government installing an independent telephone system connecting all the departments and bureaus of the Federal Government. It has been suggested that the project, if carried through, may ultimately extend the proposed service to the citizens of the district. The whole question, however, is in abeyance, and no action will be taken upon it until after the Secretary of the Navy makes his report.

A Novel Use for the Telephone

ANOTHER illustration of the many uses to which a telephone can be placed comes from Paducah, Ky. It had been decided to paint the inside of a large standpipe belonging to the water company. To do this a raft was constructed to float upon the water within the pipe and serve as a platform upon which the painters might work. A telephone was installed within the pipe and connected with the pump room of the plant. When the men had painted as far as they could they signalled the engineer to raise or lower the level of the water as desired. In this way a great deal of time was saved, as well as the cost of staging which had previously been used.

THE ELECTRICAL AGE

Established 1883

Volume XXXIII Number 4
$2.50 a year; 25 cents a copy

New York, October, 1904

Entered at the P. O. as 2d-class matter. Copyright, Louis Cassier

Electric Power Transmission on the Pacific Coast

The Bay Counties Power Company's System

By L. M. HANCOCK

Mr. Hancock's paper is one of a series of electrical transmission papers presented at the recent International Electrical Congress at St. Louis. The illustrations have been incorporated in it specially for publication here.—THE EDITOR.

AN OVERHEAD CABLEWAY IS THE ONLY MEANS OF CROSSING THE YUBA RIVER AT THE POWER HOUSE. THE BLOW-OFF FROM THE IMPULSE WHEELS FURNISHES THE BACKGROUND

IN treating of this subject it is taken for granted that the majority are familiar with the details of the Bay Counties Power Company's system, which now forms a part of the plant of the California Gas and Electric Corporation.

Only an outline of the general controlling features will be given, dealing more at length with the organization of the forces to operate the plant and carry on construction and repairs.

Considering organization, the plant falls into the following three natural divisions:—

1. Generating.
2. Transmitting.
3. Distributing.

The first comprises all water systems and power houses. The second, all high potential transmission lines and their fixtures. The third, all substations and low potential lines and their fixtures.

The main features of the plant and the attention they require are as follows:—

Diverting Dam. Log crib, rock filled, 40 feet high and about 200 feet long on the crest. The intake and headgates were of concrete and very massive and ruggedly substantial throughout. The dam needed and could get attention only during periods of low water; then it was examined thoroughly each year and whatever repairs were necessary were made preparatory to another season's submergence, which lasted the greater part of the year. The gates and intake needed some attention which was all given by the flume men.

Main Flume. Seven feet wide, 6 feet deep, 7½ miles long, through one of the most rugged pieces of canyon in the State. This was the most difficult part of the system to construct on account of inaccessibility. It was also one of the most difficult parts of the system to keep up to a high standard of repair, and on account of local conditions must be very carefully watched to avoid danger and to care for the numerous accidents as they arose. It must all be inspected each day to take care of many little things that needed prompt and immediate attention though the main repair work was attended to once a year.

The main penstock at the end of this great flume was built of concrete, and besides receiving water from the main flume was arranged to be fed in an emergency with water from Lake Francis, through 9000 feet of 36-inch wooden stave pipe, one-half mile of natural channel and 3000 feet of rapid flume. This penstock delivers water to Colgate and to the old Brown's Valley irrigation system. On account of previous troubles with the pipe lines, variations in the flow of water and the great dependence put on this plant, watchmen were stationed at the penstock and held there constantly.

The five 30-inch pipes carry the water from the penstock and deliver it into the receivers back of the power house. These pipes were very carefully installed and need only an occasional inspection, which is given by the power house superintendent or foreman after severe storms early in the spring and late in the fall.

Being covered for the greater part of the way this inspection, of course, only takes in exposed portions and surface indications, leaks, conditions of retaining walls, breakwaters, etc.

Water is distributed from the receivers to the 16 water wheels through small pipes and suitable gates. All the small pipes, connections, gates, etc., near the power house get regular attention from the forces employed there. Inspections are frequent and every item has continual care.

The power house equipment is as follows:—

GENERATORS

Three 2000-K. W., 240 r. p. m., 3-phase, 60-cycle, 2400-volt inductor.

Three 900-K. W., 360 r. p. m., 3-phase, 60-cycle, 2400-volt inductor.

One 720-K. W., 286 r. p. m., 2-phase, 133-cycle, 2400-volt inductor.

Two 50-K. W., 800 r. p. m. exciters

FROM COLGATE TO OAKLAND, WHERE THE BAY COUNTIES LINE ENDS, IS 152 MILES. FROM OAKLAND TO SAN FRANCISCO BY WAY OF THE STANDARD COMPANY'S LINE IS 70 MILES. THE TYING-IN AT OAKLAND GIVES THEREFORE A TRANSMISSION OF 222 MILES FROM COLGATE TO SAN FRANCISCO. POWER IS TAKEN BACKWARD, SO TO SPEAK, FROM MISSION SAN JOSE OVER THE ELECTRA LINE AS FAR AS STOCKTON. HERE, ENERGY AGGREGATING SEVERAL THOUSAND HORSE-POWER IS DISTRIBUTED IN EVERY-DAY HARD COMMERCIAL SERVICE AT A DISTANCE OF 218 MILES FROM ITS POINT OF GENERATION

AT THE COLGATE POWER HOUSE.—AT TIMES OF LIGHT LOAD PORTIONS OF THE STREAM SHOOT OUT INTO THE RIVER WITHOUT STRIKING THE IMPULSE WHEELS. NO ATTEMPT IS MADE TO "CONTROL" THE FLOW OF WATER BY THE GOVERNING APPARATUS, AND SOMETIMES THE STREAM REACHES CLEAR ACROSS THE CANON

Suitable tangential water wheels with deflecting nozzles are directly connected to each generator and exciter. The low-potential switching is made as simple as possible and only such instruments are centralized as are needed to control the plant. The balance are scattered about the building near the apparatus to which they belong. Oil switches are used exclusively for the 2400-volt circuits, at which voltage all the machines operate. The transformers are all oil-insulated and water cooled, the majority of them are 750 K. W., but there are a number of smaller sizes. They all require almost no care, and being in the power house, have constant attention.

All low-potential wires and cables are run in a subway, while all the high potential wires and connections are overhead in the gallery. Originally an immense amount of wood was used in the mounting of the high potential switches, lightning arresters, etc.

This construction was all destroyed in a fire, March, 1903, and has been replaced by a brick and tile and steel construction built up on the cellular system.

The unique feature of Colgate is the number and variety of very high potential circuits radiating from the plant. The following table gives a list of them:—

Name of Circuit	No. of Circuits	Length in Miles	No. of Pole Lines	Materials	Phase	No. Wires in Each Circuit	Cycles	Kilovolts
Bay	2	140	2	¾ Copper, ¼ Aluminum	3	3	60	40-50-60
Sacramento	2	61	1	60 M. Alum., 1 M. Copper	3	3	60	40
Oroville	1	28	1	Aluminum	3	3	60	40-50-60
Marysville	1	28	1	Part Alum., Copper	2	4	60	15
Nevada	1	19	1	Copper	3	3	60	24 On same pole line
Nevada	1	16	1	Copper	2	4	133	24 On same pole line

This variety of service can only be handled successfully at the power house end by either using individual transformers for each line, by using a great many high-potential switches or a combination of the two methods. The first, however, makes it necessary to have a great deal more transformer capacity than is necessary for the loads handled. The second method was pioneering to an alarming extent. Therefore the third method was adopted, planning to use as few of both devices as possible. The odd phase and voltage lines had to have separate transformers which were operated from the low potential switches, and were to all intents and purposes a part of their respective lines. The growth of the plant was such that the odd voltage three-phase

A BIRD'S-EYE VIEW OF THE COLGATE PLANT OF THE BAY COUNTIES POWER COMPANY. THE WATER COMES FROM THE NORTH YUBA RIVER THROUGH NEARLY 8 MILES OF WOODEN FLUME TO THE HILL-TOP, SOMEWHAT OVER 700 FEET ABOVE THE POWER HOUSE. THE ROAD WINDING OFF TO THE LEFT IS THAT OVER WHICH ALL SUPPLIES COME

lines could not be avoided; however, it was planned ultimately to have these all operated at the same tension.

The question of high-potential switching was one of great moment and must be solved, yet it is not to be trifled with. There were four designs of switches employed, as follows:—

First, an emergency switch, which when open or closed was perfectly safe but would not stand being opened under full voltage and heavy current. This was simply a blade about 30 inches long with jaws mounted on large insulators which were carried and held in place by suitable frame work, the blades being pivoted to one of the jaws. These switches were suitable for cutting out a dead line, or would open the full voltage of a 30-mile line if there were no load on it. They were also adapted for cutting in and out banks of unloaded transformers, but with full voltage on. They were used in series with main switches, lightning arresters and other devices that must be taken out of service occasionally without having to shut down, and were also employed for temporary work and testing.

Second, the Stanley switch, which was arranged to break the arc in a tube filled with plaster paris. This served the purpose in the absence of anything better, but was clumsy, slow of operation and often out of repair.

Third, the oil switch with horizontal break. This switch was not installed where it had to handle heavy loads, but there were some very severe tests put on it which it stood remarkably well. These tests consisted of opening a dead short at a distance of 100 miles from Colgate with full generator capacity behind the line.

Fourth, the oil and water switch. This switch in its original form was put under extremely severe tests which it stood wonderfully well, opening twenty-five dead shorts on a 40 K. W. line in quick succession, some of which were 240 miles from the generator via the pole line. However, the design of this switch was not suitable to the duties required of it. During a severe lightning storm it broke down and was not replaced. The consensus of results pointed to the horizontal break oil switch as the one that stood the test of actual service the best of any.

The sub-stations and the wiring for them were as various as could be imagined. The transformers as a general thing were wound so that they could be used anywhere on the system, and taps were brought out so that either three-phase or two-phase circuits could be fed from them. Three transformers were generally used and taps were brought out from the winding so that the voltage could be varied as needed. When two-phase service was given from three transformers, it was found unsatisfactory for motor work on account of the regulating coils varying the phase angle. In several cases a single transformer was installed for single-phase service in small towns, the high-potential side having one wire attached to one of the line wires and the other to a ground plate, very satisfactory service being given in this way in small towns.

The sub-station buildings varied from steel frames covered with corrugated iron in important locations, to an ordinary wooden building in some of the small towns.

The switchboards in a few of the larger stations were quite complete, but in the majority were very simple, there being generally apparatus to meet only the most urgent needs. High-potential switches were usually provided in each station; in the larger ones they are either Stanley or horizontal oil break; in the smaller stations is the cheapest kind of long knife switch. Devices were usually provided outside to cut the line clear from the building. Ten sub-stations were put into service when the line went into commission. In three years this number had increased to twenty-six. The majority of these stations needed little attention.

The organization of the forces to operate this system was a most difficult task. There was no experienced class to draw from, so men had to be educated for the work, and meanwhile the system had to be kept going. There must be more men than were actually necessary, yet in the trying out of so much new apparatus there was no telling how many men would be needed for emergency work. There must be no delays in repairing breaks, for finan-

APPROACHING ONE OF THE TOWERS OF THE CARQUINEZ STRAITS CABLE SPAN. THIS SPAN OF 4427 FEET IS THE LONGEST IN THE WORLD. AN ILLUSTRATION OF IT APPEARED IN "THE ELECTRICAL AGE" FOR JUNE, 1904

THE COLGATE POWER HOUSE FLUME ALONG THE YUBA RIVER

cial men the country over were watching the results, and a little parsimony might mean thousands of dollars lost in depreciated securities.

The water system consisted of the following items in the order of their importance:—

First—Main section, dam, flume and penstock.

Second—Auxiliary section, Lake Francis system.

Third—The middle section from Colgate penstock to the Brown's Valley power house.

Fourth—The lower section below the Brown's Valley power house.

The Lake Francis auxiliary system is placed second in order of importance, though as it exists it is not worthy of the place, for it is so far removed and the conduits are so small that it does little good as an auxiliary. The writer urged very strongly when the original plans were made that they divide a penstock reservoir of sufficient size to operate the plant for a few hours at least. Had this been done the operating expenses of the hydraulic system could have been kept at less than one-half of what was found to be necessary. In other words, an average of ten men are now needed if the system is kept up to the proper standard, while with the reservoir only four would be needed—a saving of $5400 per year, which, capitalized at 5 per cent., equals $108,000.

This sum plus the actual cost of the Lake Francis system would have been amply sufficient to put in the reservior suggested. This is an excellent illustration of how the design may affect the future operating expenses.

The conditions facing us were these:—The system as installed must be utilized to its fullest extent and at the least cost. With this understanding the following organization was adopted:—

Superintendent—Foreman:
- Main Section:—
  - 6 Flumemen.
  - 2 Penstock watchmen.
- Auxiliary Section:—
  - Permanent watchmen at lake.
  - One winter watchman at end of wooden stave pipe.
- Middle Section:
  - 4 Ditchmen.
- Lower Section:—
  - 1 Ditchman.

This force handled all the work well except the yearly repair work and cases of extreme emergency. Then extra men were brought in from other parts of the system or from outside sources.

While the flume was new there was no great trouble in making the natural repairs, but as it grew older, timbers began to rot, twist and crack, and repairs of magnitude had to be made. Many places were patched up, and from the very nature of things, had to be left till an opportunity came for thorough work. As long as the planking that actually held the water remained intact, the balance of the repairs could be made with extra care and expense, but when a rock would come rolling down the hill and knock out the under pinning or smash a hole through the flume itself, it was simply a case of shut down till damaged parts could be replaced.

The shutting down of 10,000 H. P., even for a few hours, was no idle matter and a thing every one dreaded.

THE FOUR ANCHORAGES OF THE CARQUINEZ STRAITS SPAN CABLES. THE DOUBLE TRANSMISSION LINES ARE HERE ALSO SHOWN COMING IN

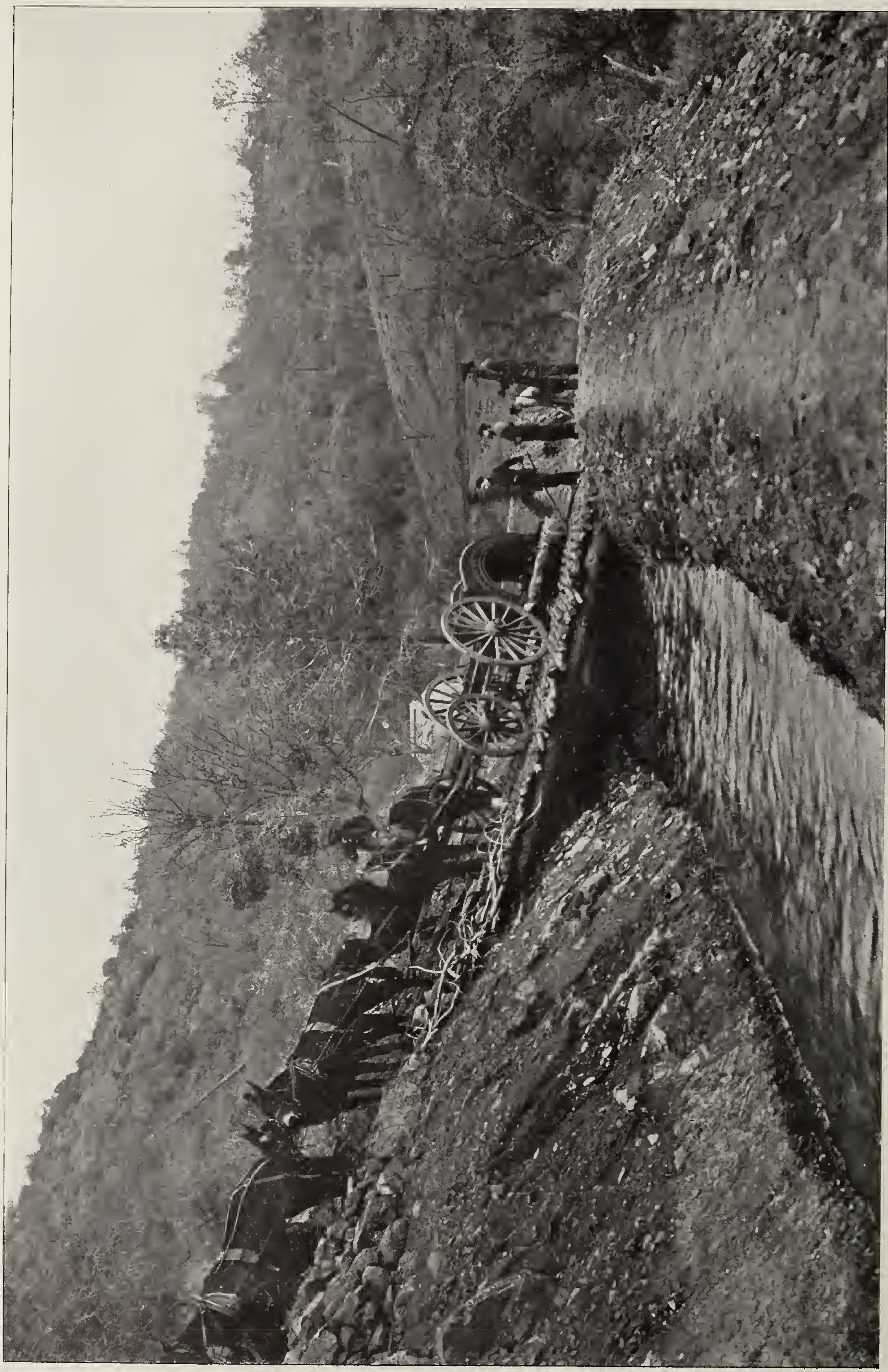
The superintendent of the water system held an anomalous position; while taking his orders from the general superintendent direct, he must at the same time take orders from the Colgate superintendent in regard to the water furnished for the power house.

He must get over the whole of his system at least every month and must be on hand to take care of any emergency that might arise on the main flume, and there were many places on this important section that had to be watched continually in order to meet difficulties half way. The foreman devoted all of his spare time on the main section, supervising repairs, looking after the placing of new material, maintaining discipline and ever holding himself in readiness for emergencies. The six flume men did little but patrol the flume; minor details they took care of, however, and always helped in cases of an accident. Two men were kept on watch at the penstock all the time.

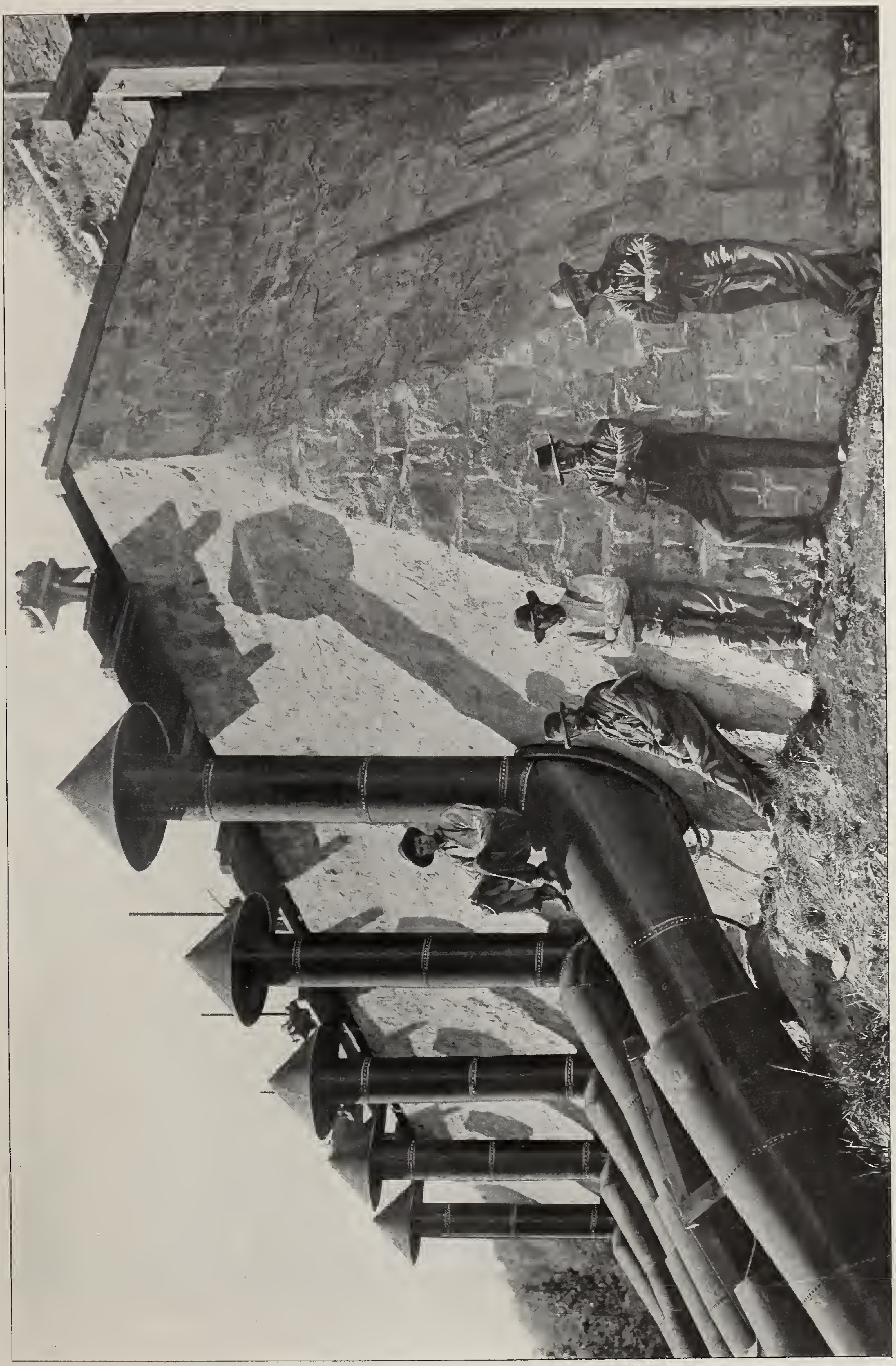
These could do but very little except to stop any leak that might occur in the neighborhood, keep rubbish off the rack at the entrance to the penstock and attend to the adjustment of the various gates in the neighborhood. If there were a break in the flume, one or both were expected to assist in its repair. There was an elaborate system of floats and electric bells installed for detecting low water at various points a mile or more above the penstock, but these devices were seldom of any value except to talk about.

When anything happened of a serious nature, the water always slacked away so quickly that everything, flume, penstock and all, was emptied before the water wheel nozzles could be closed.

There were fourteen gates to close these nozzles, each gate requiring ten minutes to operate it; hence with only



HAULING A SECTION OF AN ARMATURE TO THE POWER HOUSE. THE UP-HILL WORK IS NOT EASY



THE END OF THE COLGATE POWER HOUSE FLUME. FROM HERE FIVE LINES OF PIPE, EACH 1500 FEET LONG, LEAD DOWN TO THE POWER HOUSE. THE VERTICAL FALL IS OVER 700 FEET

CARRYING THE CABLES ACROSS CARQUINEZ STRAITS

three men on shift to do this it was quite a simple matter to predict what would happen.

On the middle section four ditchmen were employed who did practically all the repair work on their beats besides making their tour of inspection each day. This part of the system consisted of 20 miles of ditch and flume. It carried only 1200 inches of water and was an old settled piece of work.

The lower section of the water system consisted of 22 miles of ditch, and a few short flumes and inverted syphons, and as it furnished only some irrigation water and some little desultory mining, it was of so slight importance that one man handled it successfully. Each year a force of from ten to twenty men were put on for a few weeks doing general repair work. At this time every feature of the system got an overhauling, and whatever repairing it needed. Thus the whole system was put in readiness for another year of hard service.

The handling of this water system, while very exacting, involved nothing new or strange. Materials such as men were familiar with were used, and the handling of flumes was no new work for Californians with but this one exception; for power purposes without any storage, the full head must be kept running all the time, while in the ordinary service to which flumes are applied water can be turned out at any moment it may be desired without causing any serious trouble.

The water system was peculiar in that none of the men ever saw any of the customers of the company, and in fact seldom saw any but their immediate fellow workmen. Their cabins were in very isolated places, and they seldom met any of the officers of the company. Theirs was a monotonous life, with little to inspire them. Their business was to deliver water, and as long as that was done no one complained nor did they praise.

The Colgate power house was the center of the whole system and the whole aim of the operators was to put out energy.

This was dependent (a) on the water system delivering water to them; (b) on their ability to utilize it and to keep in working order the apparatus in their care; (c) on the line department keeping the lines in

THE BAY COUNTIES TRANSMISSION LINES CARRY CURRENT AT FROM 40,000 TO 60,000 VOLTS. SOME OF THE STRAIN POLES ARE HERE ALSO SHOWN

order, to transmit what they generated; and (d) somewhat, on the distribution system being able to receive and deliver to the customers what the line department handed over to them.

After the power house force had kept its apparatus in repair and in operation, they must, in order to succeed, be in harmony and in close touch with all the other parts of the plant. Hence the emphasis on a complete and efficient system of communication. This was not so evident on the water system, for immense systems of flumes and ditches have been and are operated without any means of communication other than messenger or mails.

Items (a), (b) and (d) did not interest the power house force; they must concentrate on their own troubles.

The principal item on which success depended here was the repairs of damaged or worn-out apparatus, so in order to facilitate this a large supply of new material and spare parts were kept on hand and a large and well-equipped machine shop was installed and men were appointed on the force that could utilize these tools to their full value.

The forces here, though dependent so much on the others for success, were never allowed to get the idea of covering their own mistakes by attracting attention to the troubles of others. The handling of this power house had only these three features that distinguished it from other large power houses:

First—It must feed numerous high voltage lines of various voltages, phases, cycles and lengths.

Second—It must run in parallel with other large plants that were many miles distant and operated at different voltage and phase.

Third—Its service reached almost every known business where power can be utilized, and there was not a moment in the year when a great many were not exceedingly anxious for energy.

While this was the case, the only feature of uncertainty at the start was that of the high-potential lines, switches, lightning arresters, etc., but after a year's experience it was found that to this apparatus could be charged no more than a proportionate share of the troubles.

It was decided that for Colgate there should be the following organization:—

Superintendent ranking as a division superintendent:
- Foreman:
  - Assistant Foreman:
    - 3 Shift bosses.
    - 3 Operators.
    - 3 Oilers.
    - Machinist.
    - Apprentice to Machinist.
    - 2 Telegraph Operators.
    - Repairmen as needed.

The superintendent did not have absolute authority over the flume superintendent, but in the question of water supply his word was final. Besides this he was a man of much wider knowledge and experience, which was all of very great value to the company and of which they wished the benefit. It was ordered that each should draw on the other in case of need and they must be in perfect harmony with each other. Besides having charge of Colgate, this superintendent had charge of a small power house of 1000 H. P. situated about 9 miles distant, and known as the Brown's Valley plant. On account of this, the Colgate and the water system superintendents were brought into still closer contact. The Colegate foreman had charge of all the day work, operating, repairs, new work, etc., and ranked next to the su-

ONE OF THE TOWERS OF THE CARQUINEZ STRAITS SPAN

ON THE YUBA POWER COMPANY'S LINE

perintendent. The assistant foreman had charge of all the night work and ranked next to the foreman. The shift bosses were under the foreman and and assistant foreman and had charge of the operation of the power house during their shifts.

They were directly responsible for everything that happened and the condition of the apparatus. They must see that everything was all right when they took charge and anything wrong when they came on duty must be reported at once else they would be held responsible. They were also responsible for the two men under them. Each shift was eight hours, and the operators were changed one shift ahead each two weeks. The machinist and his apprentice were free lances that had to do whatever was to be done at whatever time it was necessary. They did the greater part of repairing and improving the machinery.

The lines which have always been the "weak sister" demanded and got especial care and attention. It might be said on general principles that there never is enough money put into the lines. We will deal alone with the 140-mile line, because this is typical of how all the others were handled, especially those carrying the higher potentials. The greatest care was taken in handling them, for they were unusually long and every move was watched with the keenest interest. Failures would receive the severest censure, because reaching to the very doors of San Francisco the service we were giving would be before the public in a much more important and effective way than anything we had yet handled. If the street cars of Oakland, which were the principal load at the start, did not run, the men who handled them and the public too were not slow to blame the trouble on the source of power. Hence every detail was studied and every plan possible carried out to get complete reports of the condition of the line every few hours of the day. Elaborate precautions were taken to discover any weakness and repair it before a break down could result. However, we could not always tell just how fast things were going to happen. There were three items that required attention:

First—The watching of the line and searching for weak places as they developed.

Second—The completion of the work which the construction forces had not the time to finish and the building of new branch lines.

Third—The repairing and changing of parts that were found to be faulty or unsuited to the conditions.

To attend to these the foregoing plan of organization was adopted:—

Line Superintendent ranking as division superintendent:
- Asssistant Superintendent:
  - Patrolmen.
  - Foreman repair gang.
    - Linemen.
    - Laborers.
  - Bookkeeper.
- Telephone Expert.
- Superintendent of New Constructiontion:
  - Engineers.
  - Surveyors.
    - Rodmen.
    - Chainmen.
    - Axmen.
    - Laborers.
  - Foreman Constructing Gang:
    - Linemen.
    - Teamsters.
    - Laborers, etc.
  - Freight Distributing Agent.

ANOTHER VIEW OF THE POWER HOUSE AT COLGATE

The superintendent of lines for the first year spent nearly all his time getting back and forth along the line, studying conditions as developments came, instructing the men and keeping them up to their work. The importance of this work made great demands on the time of the general superintendent.

The assistant line superintendent devoted a good deal of his attention

DRY CREEK POWER HOUSE ON THE YUBA POWER COMPANY'S LINE

to the office work, checking reports, ordering and forwarding material, looking after the repair work and working between trips with the line superintendent.

The telephone expert was in a position that he had to work under nearly all the superintendents though he was nominally under the line superintendent. His was a study in harmony. His work extended from one end of the plant to the other, and as the name indicates, devoted the greater part of of his time to the solving of difficulties, designing and installing protective devices and working the telephone system so the highest efficiency could be obtained. He was always supplied with material and men on call. If communication could not be maintained, the plant could not be operated.

The superintendent of construction was utilized almost exclusively on new work and hence had little to do with the operation of any of the lines, except when they first went into commission. He was expected to use every opportunity to study developments in order to assist in any way possible to the general success.

In order to care for the line thoroughly, patrolmen enough were put on so that they had an average of 14 miles to cover each day. In the mountains and marshes the beats were shorter and in the valleys longer.

The whole line must be put into shape so that every part of it could be reached. In the hills trails must be dug, creeks bridged and barns built for horses. In the marshes and flooded lands boats must be provided, everywhere gates must be put in fences, and above all certain communications must be provided.

The work required that the patrolmen should not do very much of the actual labor connected with the upkeep of the line. They carried a number of tools and a portable telephone, and were always called on in emergencies. They must report on duty in the morning, get over their beat at a slow enough gait to be sure of the condition of every detail, report several times during the day and report off duty at night. Usually by the time they had attended to all the above, they had accomplished a very good day's work. Most of these men used saddle horses; in fact, there were only one or two beats where a wheeled vehicle could be used to advantage. Material was stored at various places along the line so that it could be reached conveniently in case of trouble. The work of patrolling was so new that there was no class of trained men to draw from, so each patrolman had to be educated. In fact, the officers in charge had to make an unusually close study of it, living with it almost night and day for two years. A host of questions were asked, and few of them answered before the line went into service. As the answers came they must be recognized quickly and the work pushed accordingly.

It looks a little strange to put on a repair gang almost before an installation has gone into actual service. This was on account of the work being so new that there was no experience to guide those who designed the various parts of the equipment.

Some of the questions to which we had to learn the answers in the field, were:—

To what extent will the wooden supports of the line be destroyed by the high potential used?

How will the insulators, which were a composite of glass and porcelain, stand the actual strain of operative conditions?

How much of the insulator can be broken off before it must be removed from the line?

How much dirt can accumulate on an insulator before it must be cleaned? How noisy can an insulator get before it is dangerous?

What effect will fogs produce?

What effect will rain produce?

If a line gets shut down in a rain storm, and it be started up again, with what difficulty will this be done?

How will long spans stand up?

What will be the result of using steel for line supports?

As the work progressed answers came to all of these about as follows:—

Wood pins were destroyed by the hundreds near salt water; cross-arms a few, and poles only two or three in the course of three years' service.

Glass is not suitable for high-potential insulators under the conditions as they exist on this system. An all-porcelain insulator has been and is being substituted for the composite insulator as fast as conditions will permit, especially near salt water.

The insulator first installed had so little margin of safety that if it were broken at all it was ordered removed from the line.

If only a small piece were chipped out of the edge the risk was taken for a time.

The only place where we had trouble with the accumulation of dirt on insulators was near salt water and cement works.

There may be a good deal of noise at an insulator on a wood pin for many weeks and not much damage result, but it should be watched closely. With a steel pin and a wooden cross-arm this noise will not be anything serious except in some unlooked-for place due to local conditions. These should be watched closely on general principles.

Ocean fogs cause the burning of very many wood pins, while cross-arms and poles suffer but little. Fogs a few miles back from salt water do not affect either pins, cross-arms or poles.

Rain is Heaven's own blessing on a high-potential transmission line. It cleans the insulators and stops a good deal of the damage to wooden supports. This is true of salt water districts especially. The first few drops that fall after a prolonged dry spell cause a good deal of a display, which soon passes, however, and all is quieter and better than it was before. This display does not affect the power house load to an appreciable extent nor does it affect lights or motors.

The starting of this line in a rain storm never caused the slightest trouble, in fact in changing from one line to the other full voltage has many times been thrown instantly on the dead line during heavy rain storms without the slightest disturbance that any one could detect.

The experience has been that long spans are preferable in almost every case. On a mountain line built about two years ago some very long spans were used. One was 1800 feet, with the regular line conductor, a 350,000 C. M. stranded aluminium cable, and it has given the best of satisfaction.

Every indication is that steel should be used for high-potential line supports from the ground up to the insulator throughout the system.

The sub-stations and distribution work were handled almost entirely by the local men, nearly all of whom were under a separate management. A superintendent of this work was maintained whose duties were mainly to advise the local men in regard to the handling of the company's property, and to see that it had proper care.

At the majority of the sub-stations a man would be on duty only for a time during the evening when the lighting load was on unless there was important high-potential switching to be done.

The low-potential distributing systems gave very little trouble, and it was very seldom that they were not able to utilize the current available.

The men for all the positions were very carefully selected from the whole country. The repair and construction forces were used as training schools for men for permanent positions, and the foremen of these gangs were selected with this specialty in view. These forces were used too as places to lose out undesirable characters.

The following ideas were advanced

to guide in the handling of the men:—

First—Harmony must be maintained.

Second—There must be a definite sequence of authority to prevent working at cross purposes.

Third—Each man must respect and obey the officer immediately over him.

Fourth—Each man had the assurance that his advancement depended on himself alone; that all the higher positions of the operating, repair and construction forces were open to the men handling the plant if they would fit themselves for them.

Fifth—The longer the time of service the better the pay.

Sixth—A sufficient number of men must always be kept to insure excellent service, but there must never be so many that each man's time will not be fully occupied.

The officers and the sequence of their authority for the whole system were as follows:—

- General Superintendent:
  - Water System Superintendent:
    - Foreman.
      - Flumemen.
      - Repairmen.
      - Emergency men.
    - Auxiliary Section:
      - Lake watchman.
      - Winter watchman on wood stave pipe.
  - Middle Section:
    - 4 Ditchmen.
  - Lower Section:
    - 1 Ditchman.
- Colgate Superintendent:
  - Foreman:
    - Assistant Foreman:
      - 3 Shift bosses.
      - 3 Operators.
      - 3 Oilers.
      - Machinist.
      - Apprentice to Machinist.
    - 2 Telephone operators.
    - Repairmen, etc.
- Superintendent of Lines:
  - Assistant Superintendent:
    - Patrolmen.
  - Foreman Repair Gang:
    - Linemen.
    - Laborers, etc.
- Superintendent Construction:
  - Engineers.
  - Surveyors.
    - Chainmen.
    - Rodmen.
    - Axmen.
  - Foreman:
    - Linemen.
    - Teamsters.
    - Laborers, etc.
  - Time-keeper.
  - Freight agent.
- Superintendent Sub-stations.
  - Sub-station operators.
  - Local managers of business districts.

Some German Electric Tramway Data

According to the "Electrotechnische Zeitschrift," current for German electric tramways is almost universally taken from overhead wires. There are a few lines or sections in Berlin, Dresden and Düsseldorf, where slotted conduits are worked, however. Pure accumulator traction is found only on some local lines in the Pfalz (Palatinate) and on some Bremerhaven streets, where horse trams are otherwise running; in both cases the battery cars will soon disappear. The third-rail system is in use on the elevated and underground railway of Berlin, and on the electric railway Berlin-Gross Lichterfeld.

Two systems of trackless roads have found favor, the systems of Schiemann, and of the Allgemeine Elektricitäts-Gesellschaft, both being utilized for passenger and goods traffic. One of the Schiemann lines has a length of 8 kilometers (5 miles). If tramways absorb about 50 watt-hours per ton-kilometer, the power consumption of the trackless cars may be estimated at 125 watt-hours, yet the latter have their advantages under certain conditions.

The outlook for the future development of electric tramway lines is not promising. Of towns there remain practically only four, Bradenburg, Potsdam, Mianz and Rostock, where horses are to be superseded and the electric light railways have not advanced during the year 1903. This is rather striking, considering that so far only 5 per cent. of the German light railways have adopted electric propulsion.

Execution by Electricity

Referring to the article entitled "Execution by Electricity" in the September number of this paper, Mr. K. L. Aitken, chief engineer of the Electrical Supervision Society, of Toronto, Canada, writes:

"My opinion on the subject differs radically from those expressed, and being based on experience, I do not hesitate to state it. I had the pleasure some years ago of getting across a 550-volt direct-current circuit, with both hands very damp with perspiration. I will not deny that the sensation was very painful, but I strongly maintain that the interval of time required to lose consciousness was a fraction of a second, and that it did not seem longer than this.

"In a great many cases of hanging, post-mortem examination shows that death is the result of strangulation, and therefore, to my mind, this method of execution savors of barbarity. Electrocution, on the other hand, must, I believe, produce almost instantaneous unconsciousness, and will, for this reason, be universally adopted unless some drug scheme such as the correspondent of the 'Medical Record' suggests, be taken up.

"The remarks on the subject by Mr. A. B. Brooks do not seem to show anything, as it is prima facie evidence that the current was not of sufficient intensity to produce unconsciousness at once.

"In electrocution, when the frequency and voltage are being changed for the final application, the circuit must, of necessity, be opened and closed again. This produces muscular activity to a marked degree, and conveys the ghastly impression to the spectators that the criminal is not dead, although I believe that death comes with the first application. If current were made to flow through the body of a person who had died from some disease, and who was unquestionably dead, I think the same muscular contortions would be seen.

"I have this to offer in the support of my opinion: How many men have been accidently shocked through the head and with good contact, with such voltage and frequency as used for criminal electrocution, and have been resuscitated, even though the best medical attention was close at hand?"

The recent completion of the Camden & Suburban and Camden & Trenton Railways makes a continuous trolley line between Philadelphia and Trenton, a distance of 36 miles, and makes its possible to go from Philadelphia to New York by electric cars with but one change. The distance is 104 miles, as against 90 miles by the Pennsylvania Railroad, and nine hours are consumed in the trolley trip, as compared with two hours and ten minutes by rail. The fare for the entire distance is $1.05.

The first electric locomotive purchased by the Philadelphia & Reading Railroad has been delivered by the Westinghouse Electric & Manufacturing Company, of Pittsburg, and is now in service on the Cape May, Delaware Bay and Sewell's Point Electric Railway, which extends from Cape May Point, N. J., to Sewell's Point, Va. The locomotive is to be used exclusively for hauling freight over this line, and is especially adapted for the service required. It is 23 feet long, weighs 40,000 pounds, and is designed to haul a maximum load of 450,000 pounds at a maximum speed of 10 miles an hour.

Wind-Mill Electric Plants

By HANFORD C. JUDSON

THE wind-mill as a motor for generating electricity, has its chief advantage in its simplicity. Its greatest disadvantage is that the wind is neither continuous nor constant. It blows briskly and evenly one day, and is capricious the next. This makes it necessary to store the electric energy, generated when the wind is blowing, to assure a sufficient supply whenever it is needed. The wind, however, may be depended on to give, from year to year, in any locality, a nearly constant amount of power through an air motor. This potentiality of the wind is usually tabulated in terms of its mean average velocity, because the velocity of the wind determines the pressure that it exerts on the vanes of the mill, and this pressure is the first factor in determining its power.

Tables have been published, giving the mean average velocity of the wind at different points on the map. It varies considerably. The average for the United States is 8 miles an hour; but the average for Atlanta, Ga., is only 4 2-10 miles, while at Sandy Hook, N. J., it is 4½ miles an hour. From this it will be seen that a wind-mill might give great satisfaction in one place, but might be entirely inadequate in another.

A wind-mill does not return in useful work all the energy of the wind. This can be shown best by a practical example. If we take, for instance, the mean average velocity of the wind, tabulated for the city of Philadelphia, Pa., as 10 miles an hour, it means that the wind effect there is as though it blew at that rate continuously, though it is the mean of a great many variations. As no machine can work at all speeds at the same efficiency, there is obviously for the wind-mill a certain maximum and a certain minimum speed, between which it must be designed to regulate, if the best work is to be obtained out of it.

It is found in practice that the best working speeds for a wind-mill, in places where the mean average wind velocity is over 8 miles an hour, lie between two and a half times the mean velocity and 60 per cent. of that product, and where the mean velocity is 8 miles or less, the best speeds are between twice the mean velocity and 60 per cent. of that product. According to this empirical rule the mills at Philadelphia should automatically take up the load only after the wind rose to 13 miles an hour, and that after it reached 25 miles an hour it should regulate to keep the speed down, thereby losing any further increase in power.

The first cost of the wind-mill-driven electric generating set, is considerably greater than the first cost of an oil or steam-engine-driven plant; but when it is once paid for it will deliver power without further expense, except the cost of maintenance and repair, which, for the wind-mill itself, need not be heavy. If it were not for the storage battery, the ordinary hired man could be entrusted with the whole electrical and mechanical outfit; but the battery requires the attention of some one who knows its kinks, if it is to be depended upon. A fool-proof electric storage battery is in fact the great desideratum for small wind-mill electric plants on farms or country places.

Other methods of storing the energy have been suggested to get around using secondary batteries. One is to pump water into a tank, high enough to give a good head, and to generate electricity by a turbo-generator using the power directly. The work on a farm might be organized so that the need of current would be coincident with sufficient water to give it; but it would need a flow of 100 gallons of water a minute, with a head of 100 feet to generate 2 H. P. in a turbine, and it would need a tank 20 feet in diameter and 10 feet high to store enough water to give this for three hours consecutively. This method could, therefore, be used only within narrow limits, as the cost of tanks to hold water enough for large amounts of power would be prohibitive, as would also the expense of pumping into reservoirs on a hill side for such a purpose, except in very special cases.

Another suggestion is to compress air, using it to drive the dynamo when the power is needed. The expense and care of this kind of a plant at present, however, would hardly be less than that of the battery plant.

These suggestions are more valuable as pointing to possibilities than as facts of practical experience. It certainly ought to be possible to devise some means of storing the wind's energy, simple enough to use in isolated electric plants. The reward of successful investigation in this field would be almost immediate, for there are demands constantly being made on wind-mill manufacturers for air motor electric plants which they are unable to supply at any price within the possibility of the customer's pocketbook on account of the expense of the storage battery.

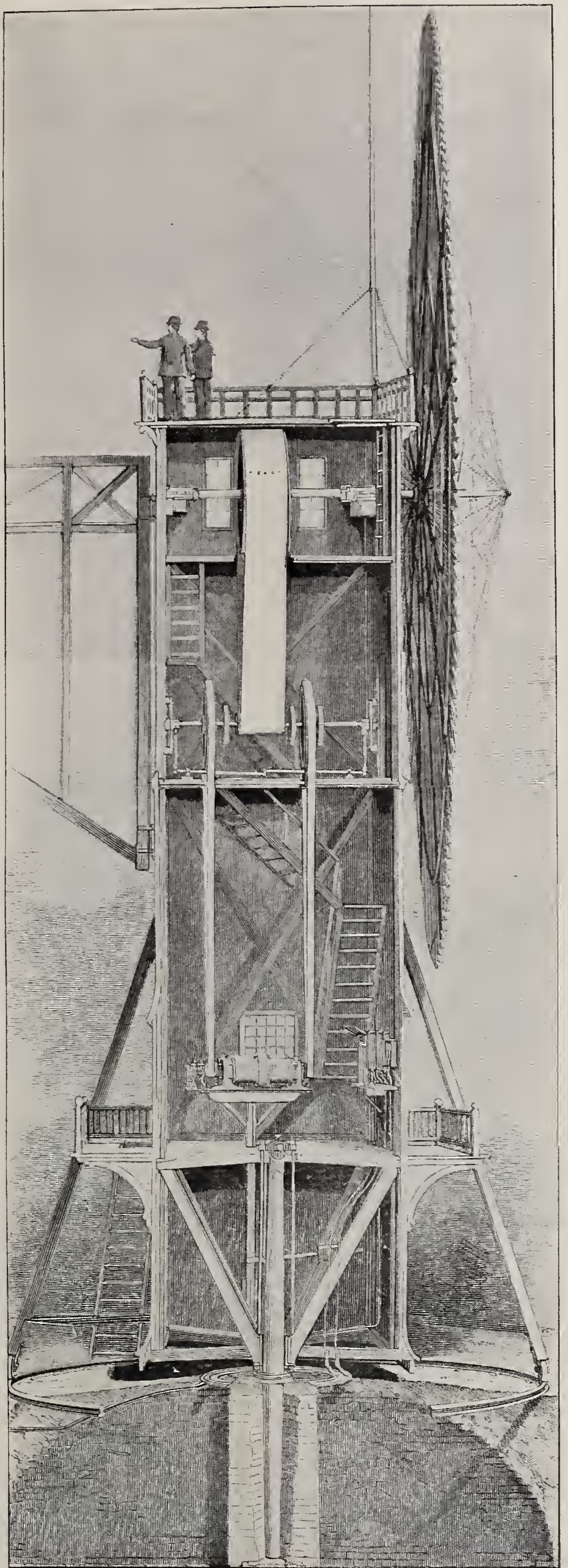
Still, it is reported that the use of wind-mills for driving electric generators for commercial service is increasing in northern Europe; though there is probably not a commercial wind-mill electric plant in America. This is easily accounted for. The strictures of competition are more severe in Europe than here, and there they are driven to utilize forces that we, with our greater resources, habitually neglect.

Though, as just remarked, there is no commercial wind-mill electric plant in America, there is a very interesting isolated plant of this kind owned by Dr. Charles F. Brush, the inventor of the arc lamp and a pioneer in electrical work. It was installed by him at Cleveland in 1889, and was used to light his house and grounds and to run motors in his laboratory. When central station lighting was brought into his neighborhood, he supplemented his wind-mill station from that source, and to-day uses the wind-mill principally to supply direct current to the motors in his dwelling and laboratory.

Dr. Brush's plant was described fully in the "Scientific American" ten years ago. The dynamo was designed by Dr. Brush himself, and is mounted on a vertically sliding support. It is partially supported by a counter-weighted lever and partially suspended from a countershaft by two belts passing over pulleys, one at each end of the armature shaft. This countershaft is, in turn, suspended from the main shaft by the main belt, its ends being journaled in sliding boxes connected by equalizer levers, which cause both ends of the shaft to move alike. Thus the right tension on the belt is always secured.

The pulleys are so proportioned that the dynamo makes fifty revolutions to one of the wind-mill. The normal

DR. CHARLES F. BRUSH'S WINDMILL ELECTRIC PLANT AT CLEVELAND, OHIO, SUPPLIES CURRENT FOR LIGHTING HIS HOUSE AND GROUNDS AND FOR RUNNING MOTORS IN HIS LABORATORY



A SECTIONAL VIEW OF DR. BRUSH'S WINDMILL PLANT. REPRODUCED FROM THE "SCIENTIFIC AMERICAN" OF DECEMBER 20, 1890

speed of the dynamo is 500 revolutions a minute, and its normal full load 12,000 watts. The automatic switching devices put the dynamo in action at 330 revolutions per minute, and an automatic regulator keeps the potential at 90 volts or below. The working circuit closes automatically at 75 volts and opens at 70 volts. The field of the dynamo is slightly compounded, and its brushes are rocked automatically as the load changes.

There were originally installed in the basement of Dr. Brush's house 408 secondary cells, arranged in twelve batteries, of thirty-four cells each. These batteries were charged and discharged in parallel, and had each a capacity of 100 ampere-hours, and the whole was used to light 100 16-candle-power incandescent lamps for every day service, there being a connected load on them of 350 incandescent lamps of from 10 to 50-candle-power sizes. There are eleven of these batteries in use to-day and in fair condition, the twelfth having been dismantled about two years ago to furnish material for patching the others, though only a little has been so used thus far, and no new plates have been put in since the beginning. "This," Dr. Brush writes, "is certainly a remarkable showing for batteries."

Besides Dr. Brush's plant, another clever application of electricity has been made to wind-mill practice by A. J. Corcoran of Jersey City, N. J., who installed a wind-mill for one of his customers over a well in New Jersey which subsequently went dry. It happened that there was another spring a short distance off, just too far to pump from directly. To get around the difficulty, a dynamo was connected to the wind-mill, where it stood, and an electric motor-driven pump was installed at the spring and run by current from the dynamo. In starting up there is scarcely any load on the mill, which is a great advantage. When the voltage is high enough the motor is thrown in circuit and then pumps as long as the dynamo furnishes power. It will be noticed at once that the cost of both motor and generator in this case, is extra, and would have been unnecessary if the mill could have been moved to the spring.

There are several commercial wind-mill electric plants abroad. In a recent article in the "Canadian Engineer," Dr. Alfred Gradenwitz described a small plant at Askor, Denmark, which has been in operation since last autumn. It is supplemented by a gasoline engine, to be used when the wind is too light to drive the mill. This plant has brought in a net revenue of 12½ per cent. on the original investment, the electric current being supplied to consumers at the same price that is paid in Copenhagen.

The interesting feature of this plant is its belt-regulating device. This consists of two pulleys mounted on a shaft which is carried by a frame, the frame being hinged at one end and counter-weighted at the other. It is supported by the main belt, which passes around one of the pulleys, the other pulley being belted to the generator. By this means the tension on the belt is kept constant, depending on the counterweight, and the surplus energy of the mill is taken up by the belt slip. The battery circuit is furnished with an interrupter, which opens when the wind power is not sufficient to give a charging voltage, and closes again when a puff of wind brings up the speed, so that the plant needs attention only at morning and evening.

A wind-mill electric plant at Wittkeil, in Schleswig, was described in "Engineering" for October 26, 1900. There, a shunt dynamo, 700 revolutions per minute, 160 volts and 120 amperes, is installed to light the town of Wittkeil. The positive field-terminal of the dynamo is connected to the battery pole, and the other is joined to the switch of the regulating cells in the charging circuit. No manual regulating of the dynamo is required, and no automatic device for disconnecting the dynamo has been provided, as the mill keeps its speed up well. The voltage in the discharge circuit is maintained at 110 volts by another automatic switch. Small motors and lamps are connected to the battery, which has a

capacity of 66,000 watt-hours. Larger motors are connected directly to the dynamo.

The London "Electrical Engineer" of September 18, 1903, notes that two factories, one near Leipsic and one near Hamburg, have been driven successfully by wind mills which are also used for generating electricity for lighting. The same paper for March 30, 1900, states that a wind-mill electric plant has been installed at Boyle Hall, West Ardsley, in England, where the battery has a capacity for running 109 lights for eight days in winter, and for fifteen days in summer.

On Nansen's ship "Fram" there was a wind-mill electric set installed to give power during its Arctic voyage, and a similar set was placed on the ship "Discovery," during its Antarctic voyage.

The Metropolitan Street Railway system of New York City have adopted a new automatic switch, which is to be installed in place of those now worked by hand by switch tenders. The new switches will be operated by motormen from their car platforms.

An Electric Truck for Drawing in Subway Cables

THE old way in which electric cables were hauled into subway conduits, and indeed the one which still most generally prevails, was to employ a capstan operated by man-power—a tedious, slow process, and it is obvious that any means of facilitating this work in overcrowded city streets is very desirable.

In one place a hoisting machine driven by an electric motor is now used for this purpose with much success, the electric motor, on account of the readiness with which it can be controlled, being found well adapted to this service. The current for the motor is drawn from any neighboring overhead power or trolley wire.

In the city of New York, where trolley wires are not available, a large electric auto-truck, carrying a storage battery and hauling machinery driven by an electric motor, is used by the New York Telephone Company for this service. The truck is also capable of carying one or two large reels of cable. This vehicle is self-propelled to the edge of the manhole of the conduits, when a wire rope is passed over a drum and through a duct to the end of the cable at a distant manhole.

When everything is in readiness, the electric motor is set in motion, thus hauling the cable into the duct with a celerity at least three times that of the manually-operated capstan method. The cost of drawing cable into the subway has thus been lessened by about 60 per cent.

Another advantage of the electric truck is that cable may be transported more readily and for greater distances than can be accomplished with horses. The truck is also used for emergency work at night, the storage batteries furnishing current for incandescent lamps to light up the manholes in which the men are at work.

Arrangements for an international electrical exhibition to be held in December at Madison Square Garden, New York, are progressing satisfactorily. The exhibition will be under the management of the Electrical Contractors' Association of New York City. J. R. Strong is chairman of the executive committee.

THE NEW YORK TELEPHONE COMPANY'S AUTO-TRUCK FOR DRAWING TELEPHONE CABLES INTO UNDERGROUND CONDUITS.—TAKING A CABLE DRUM ABOARD

THE TRUCK RUNS UP TO A MANHOLE; A WIRE ROPE, PASSING AROUND A MOTOR-DRIVEN HOISTING DRUM ON THE TRUCK, IS HITCHED ON TO THE CABLE END AT A DISTANT MANHOLE, AND THE CABLE IS PULLED THROUGH WITH DESPATCH AND ECONOMY

Single-Phase Electric Railroads

By W. A. BLANCK, Electrical Engineer of the Chicago & Milwaukee Electric Railroad, Highwood, Ill.

From a Paper Read Before the American Institute of Electrical Engineers

IN perhaps no line of electrical industry has there been greater activity than in that of interurban railroad construction, until at the present time not only throughout the whole United States, but particularly in the Central States, has this development reached a magnitude entirely beyond the expectations of the most sanguine of a decade since. In fact this development has gone so far that in some sections most of the best propositions are already exploited; however, there are still a great many, which, while of doubtful value with the present direct-current system, involving the use of rotary converter sub-station and low trolley voltage, would be very profitable in case a system can be developed which will materially reduce the cost per mile. For some time the perfection of a single-phase motor has been suggested as the solution of this problem, since it allows great reduction in the cost of the transmission system.

The present activity in the evolution of the single-phase railway motor gives added interest to the problem of developing and perfecting of all details of the single-phase system.

The consideration of the fundamental characteristics of the motors, some details in the construction of the line, and the noticeable decrease in the costs of a typical line with high voltage trolley and static transformer stations in the single-phase railway system will be the subject of this paper.

The first vital question which arises is the development of a single-phase alternating-current motor which will operate satisfactorily under the conditions imposed by railroad service. The importance of this problem was early recognized and its solution has been the aim of many of the ablest engineers both here and abroad.

While the attention given by the technical press to this subject has familiarized all with the single-phase motor, a short account of the present state of the art will not be out of place.

SYNCHRONOUS MOTOR

Since the synchronous motor requires a separately excited field, has no starting torque, and cannot be run at variable speed, its direct application in railway traction is impossible. It has, therefore, been proposed by Ward Leonard to use the synchronous motor in combination with a direct-current generator, the latter to furnish direct-current to the standard axle motors as shown in Fig. 1, which has been lettered so as to be self-explanatory.

INDUCTION MOTOR

The induction motor shows the same peculiarities in respect to starting and speed control as the synchronous motor, but to overcome these, Bion J. Arnold proposes a suitable combination of the induction motor with a mechanical storage battery, consisting of an air compressor and tank. The various members of this combination are indicated in Fig. 2. In this system both parts of the motor are free to rotate and maintain a constant relative speed. The rotor is geared to the axle and also connected to one air cylinder. The stator is connected to a second air cylinder, in which air is being compressed, when the car is running at less than full speed. With the car running at full speed the stator is at rest and no compression work is done. By admitting air to this cylinder and rotating the stator in the same direction as the rotor, the car can be run with over synchronous speed.

This combination with the induction motor continually running makes it possible to store energy when the car is coasting or stopped and to utilize this energy during acceleration. It is further seen that this system allows the operation of the car by compressed air for a limited period in case it is desirable to run without overhead conductor.

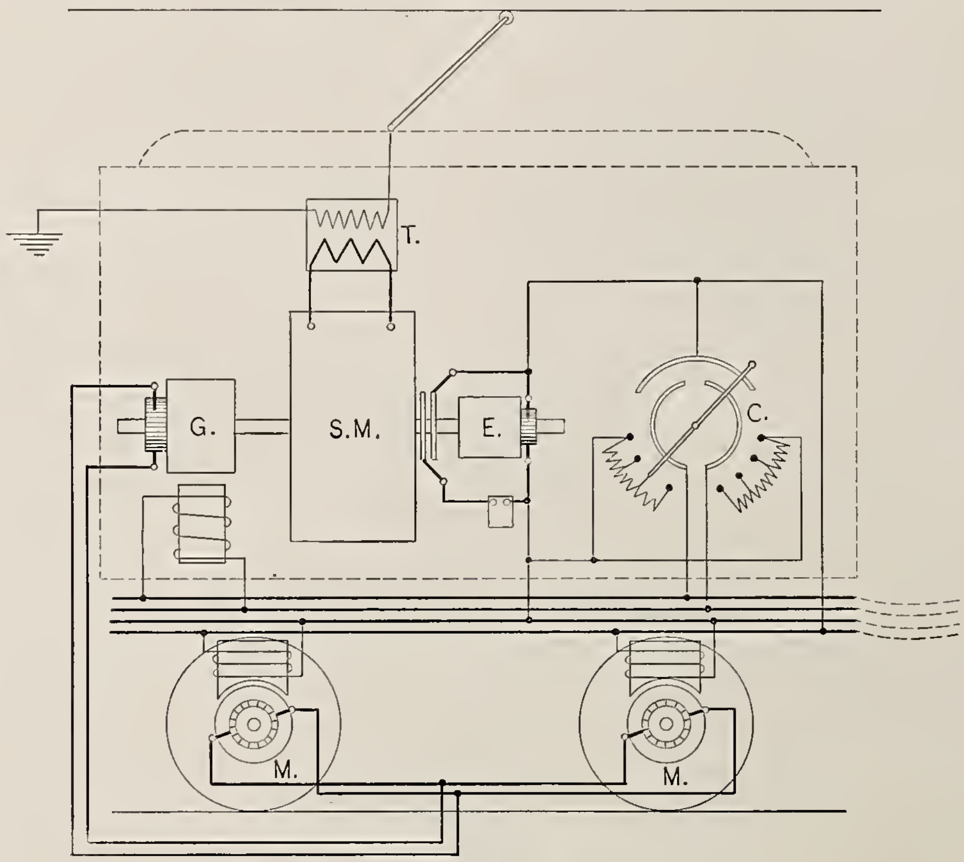


FIG. 1.—SYNCHRONOUS MOTOR. WARD LEONARD

SERIES MOTOR

The alternating-current series motor, as proposed by Lamme and Finzi, made by the Westinghouse Company, possesses all the characteristics of a direct-current series motor, and is, therefore, directly applicable to railroad work. As shown in Fig. 3, the current passes in series through the field and armature, which latter is similar to the ordinary direct-current drum type armature with commutator. As the direction of rotation in the ordinary direct-current motor is not de-

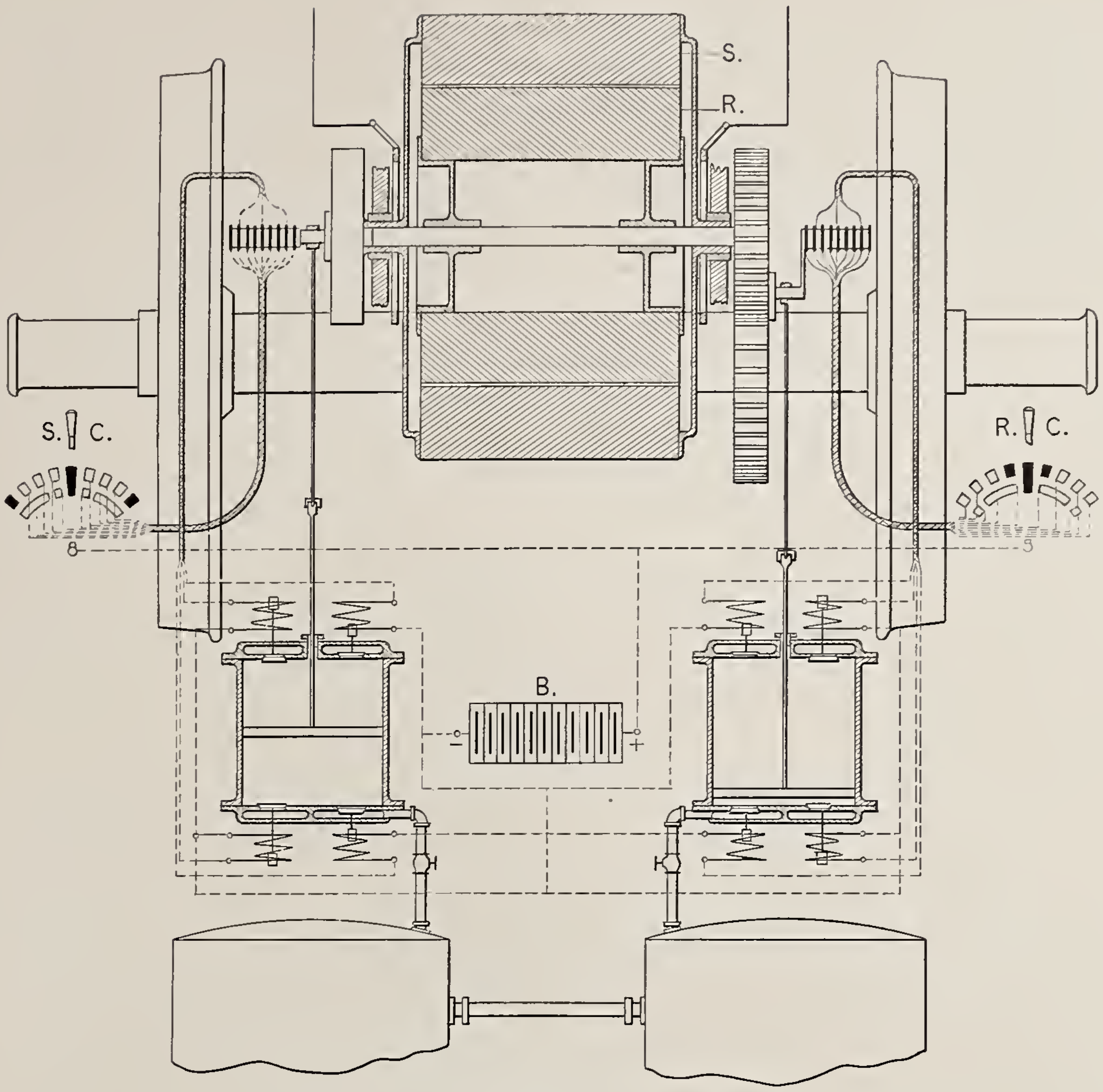


FIG. 2.—INDUCTION MOTOR. B. J. ARNOLD

pendent on the direction of the current, it is seen that it will operate with alternating as well as with direct-current.

Since the series commutator motor cannot be operated at high voltage, it is necessary to use a step-down transformer in connection with a high-tension trolley, thus increasing the weight of the car equipment.

REPULSION INDUCTION MOTOR

The repulsion induction motor developed by Steinmetz and Schueler, made by the General Electric Company, shows in general the same performance as the straight series motor, and can be fed directly from the high-tension trolley, since, as it is indicated in Fig. 4, the armature is independent of the field. The current is induced in the armature by transformer action and can be of any desired voltage. The brushes are short-circuited and placed at such angle as will give best running conditions.

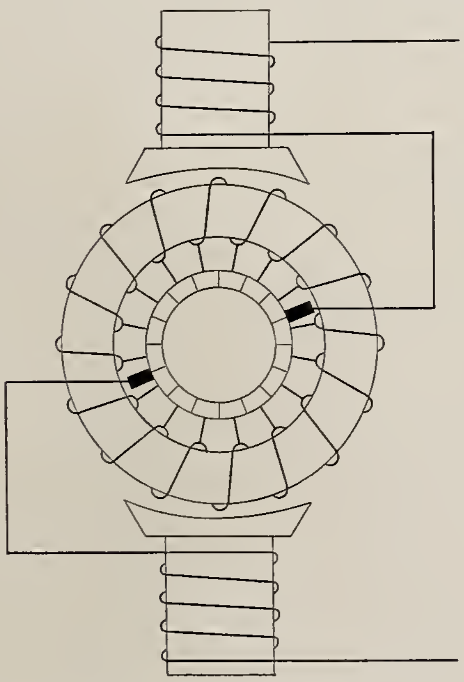


FIG. 3.—ALTERNATING-CURRENT SERIES MOTOR. LAMME AND FINZI

REPULSION SERIES MOTOR

The repulsion series motor developed by Winter-Eichberg, and built by the Union Electric Company, Berlin, Germany, is similar to the repulsion induction motor with the addition of a second set of brushes, displaced 90 degrees from the short-circuited brushes, as shown in Fig. 5 Through these brushes current is supplied by a series transformer, for the purpose of decreasing the sparking at less than synchronous speed, and at the same time securing the important additional advantage of raising the power factor nearly to unity.

CONTROLLERS

In general the operation of the last three motor systems is effected by master controllers operating suitable controllers to get the desired combinations. Induction regulators are used in all three cases to secure the voltage variation necessary for speed control, thus avoiding the losses consequent to the rheostatic control of the direct-current system.

CAR WIRING

In order to protect passengers and crew from the high potential used in this system, it is necessary that the wiring should be done in metallic conduit; this should be connected to the trucks so that any defect in the insulation of the circuit will result in the tripping of the automatic circuit breaker in the car. Moreover, it will be necessary to insulate the steps and hand-rails to guard the passengers from shocks, which might result from wet weather or car standing on a dirty rail.

TROLLEY BOW

With the high-tension working conductor it is necessary to provide against any possible short-circuiting of the trolley and its suspensions. On account of the serious results which would follow the slipping of the trolley pole so common in the present system, a suitable bow must be used instead.

The bow should be of such length that no manipulation will be necessary

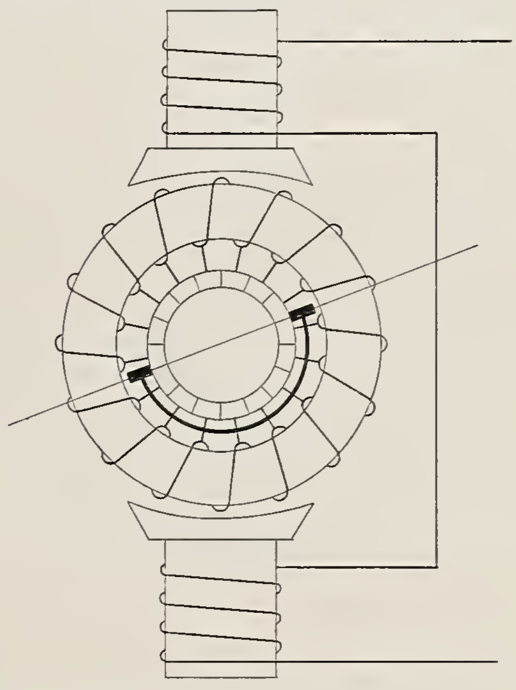


FIG. 4.—REPULSION INDUCTION MOTOR. STEINMETZ-SCHUELER

in reversing the car. This trolley bow is mounted on a well insulated platform on the roof of the car, which also supports the springs necessary to maintain the requisite pressure between the bow and the trolley wire. A small air cylinder, mounted on the same platform, operated by compressed air from the brake system, should be so connected as to lay the bow flat on the roof of the car, in case the necessity arises to temporarily disconnect the bow from the trolley.

The contact part of the bow can be made either of soft copper or aluminum, and the necessary lubrication is accomplished by grease applied in a slot extending the length of the bow.

The bow trolley in use on the Valtelina road in northern Italy, with a working pressure of 3000 volts, consists of copper cylinders rolling in insulated ball bearings. Brushes take the current from these revolving cylinders to the steel tubes carrying the contact piece.

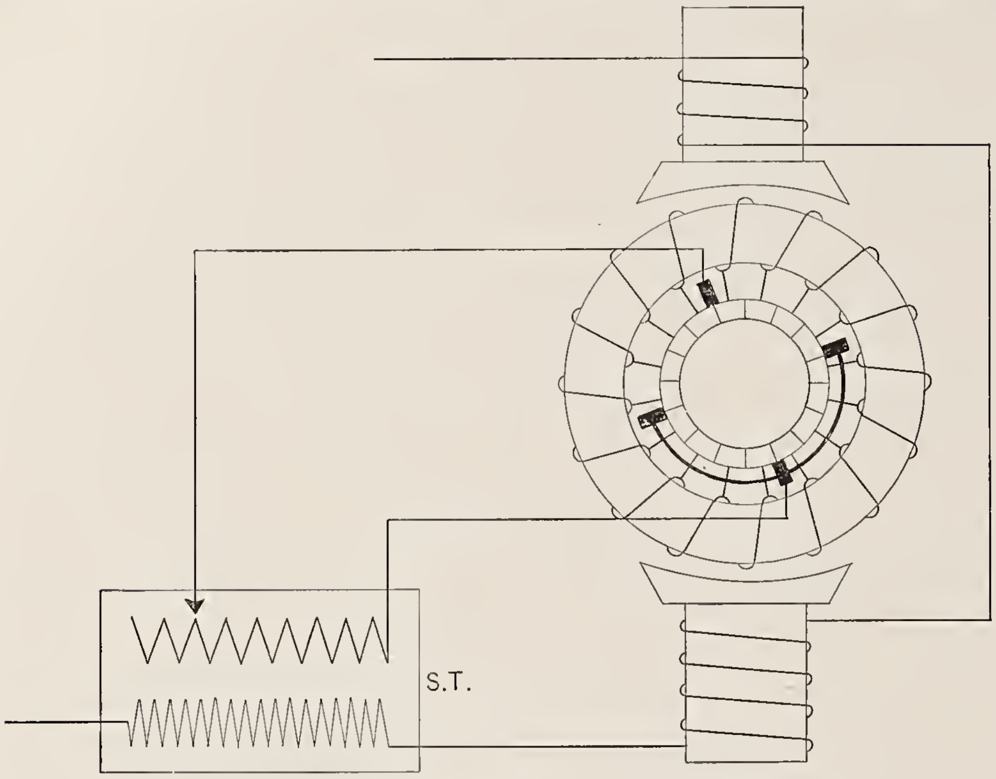


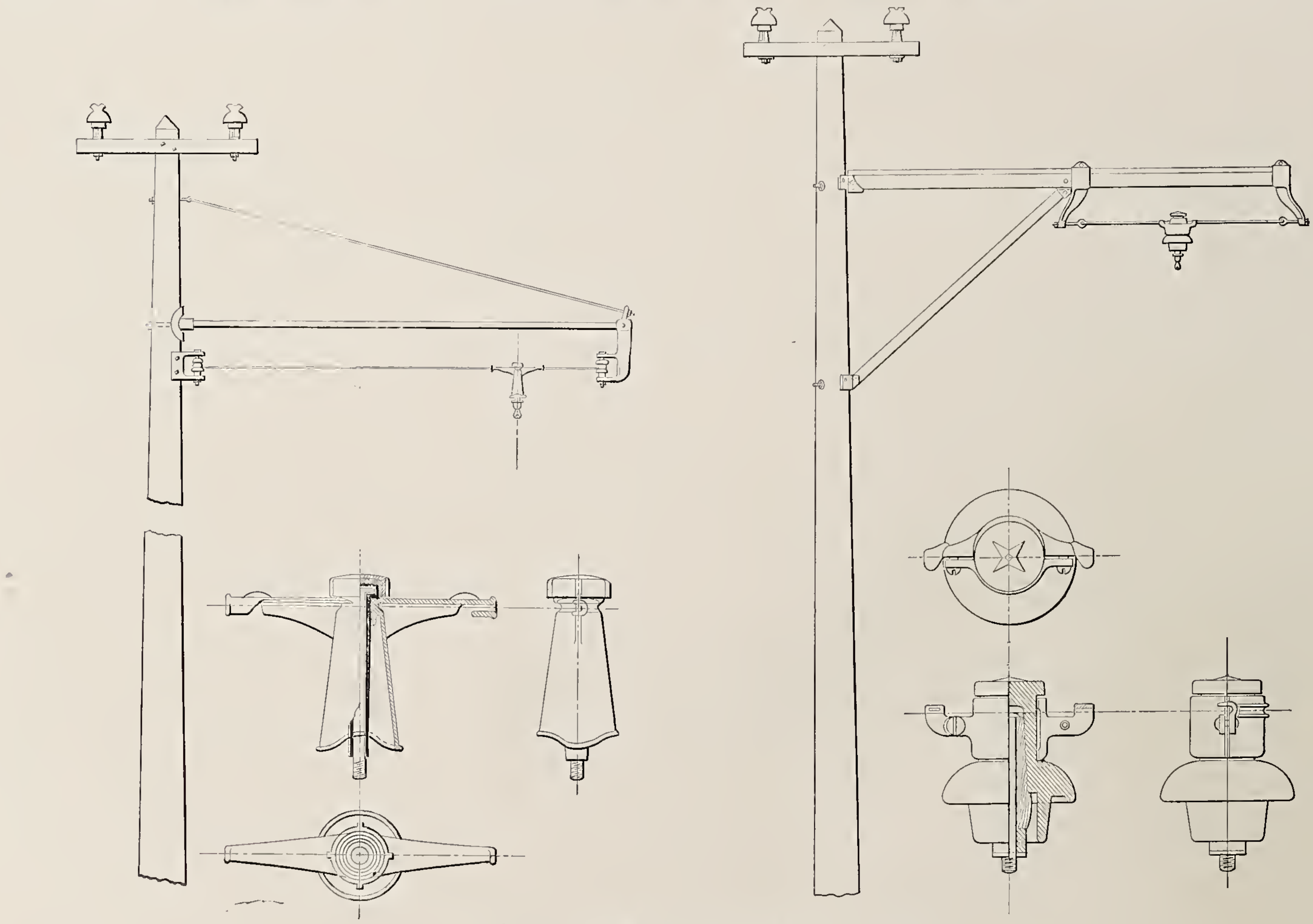
FIG. 5.—REPULSION SERIES MOTOR. WINTER-EICHBERG

TROLLEY-LINE CONSTRUCTION

Great care must be given to the construction of the high-tension trolley line in order to avoid damage to life and property. Notwithstanding the prevalent idea that the danger of these high-tension trolleys will handicap the development of alternating-current railroads operated over public property, there is no reason why they should not be made as safe as the high-tension distributing systems of lighting companies, now so common on public property. It is of first importance to provide such a hanger as shall readily withstand the working pressure of the system and can be easily replaced in case of mechanical or electrical defect.

Fig. 6 shows a trolley line construction with hangers similar to that used on the Valtelina Railroad. The bolt carrying the trolley clamp is surrounded by an insulating compound, called amborine, and set into a malleable iron bell provided with clamp arms to secure it to the span wire. A cast iron cap screw holds the insulated bolt firmly in place.

Another construction used on the Lansing, St. Johns road, in Michigan, is given in Fig. 7. The hanger consists here of a special high-tension glass insulator fastened to the span wire in the usual way. The working conductor is carried by an iron pin inserted in a wooden sleeve, on which a thread is turned to fit the glass of the insulator. A thin lead bushing allows the insulator to be firmly clamped by the malleable iron supports, thus preventing the hanger from jarring loose.



FIGS. 6 AND 7.—SPECIMENS OF LINE CONSTRUCTION

If the road passes along a public highway, special precautions should be taken to avoid accident. One solution is shown in Fig. 8, in which the working conductor is suspended at intervals of about 10 feet from two steel wires. In case of mechanical break in the trolley wire, it is evident that the end cannot reach the ground or injure passers-by. It might be noted in passing that this construction increases the carrying capacity of the trolley with but slightly greater investment. A construction somewhat similar to this is in use on the single-phase railroad near Berlin.

In regard to rail return, it may be said that with the proposed frequency of 25 cycles per second, and the small current required with the higher voltage, this portion of loss will be even smaller than in direct-current work, so that for normal interurban service it will be sufficient to bond only one rail. This has the advantage greatly to be desired in many cases of leaving the other rail free for the purpose of block signals. Furthermore, the evils of electrolysis are completely avoided with the alternating-current system.

In order to consider more in detail the relative merits of the alternating-current and direct-current systems of distribution, parallel computations and diagrams may be made for the case of a 60-mile single track interurban road. We will assume the power house to be located at the center of the line, and to contain one sub-station, and that the four remaining sub-stations are located at equal intervals on the line as shown in Fig. 9. Although the alternating-current system would not require sub-stations at so frequent intervals, they are retained, as in the direct-current system, on account of the advantage to be derived from the sectionalizing of the line and the more advantageous distribution of power due to the larger number of feeding points.

The schedule proposed consists of five local cars having one hour headway, one express car, making the round trip in three hours, and one freight and baggage car making the trip between the two terminals in about eight hours.

The average power required by the various cars in kilowatts will be as follows:

	Weight in Tons	Schedule Speed in m. p. h.	Watt-Hours per Ton-Mile	K. W.-Hrs. per Trip	Average Power in Kilowatts
Local car	30	25	80	144	60
Express car	35	42.8	110	231	165
Freight car	30	12.5	70	126	25

With the schedule outlined above, the average load on all five sub-stations will be about 500 K. W. or 100 K. W. per sub-station, while the maximum load per sub-station under certain conditions is 450 K. W., as when, for instance, the case arises that the express car is starting and two locals are running in one section. With a proper momentary overload allowance this assumed condition will require one 300 K. W. rotary converter per sub-station to be installed in the direct-current system. In the alternating-current system, however, a static transformer of 200 K. W. capacity per sub-station will be ample. The maximum load at the power house will be 800 K. W. and two 400-K. W. units will suffice, if for the purpose of this comparative study no reserve capacity be provided either in power house or sub-stations.

Some idea of the relative simplicity of the transmission systems in the two cases may be obtained from the consideration of the accompanying wiring diagram, Fig. 10, showing the apparatus and connections required in each case. In both cases step-up transformers raise the total generator output to the high transmission voltage, and a step-down transformer set is placed in the power house. Although the power house sub-station could take its supply directly from the generators, it was preferred to use one general form for all sub-stations, and thus avoid special switch arrangements.

For the three-phase transmission

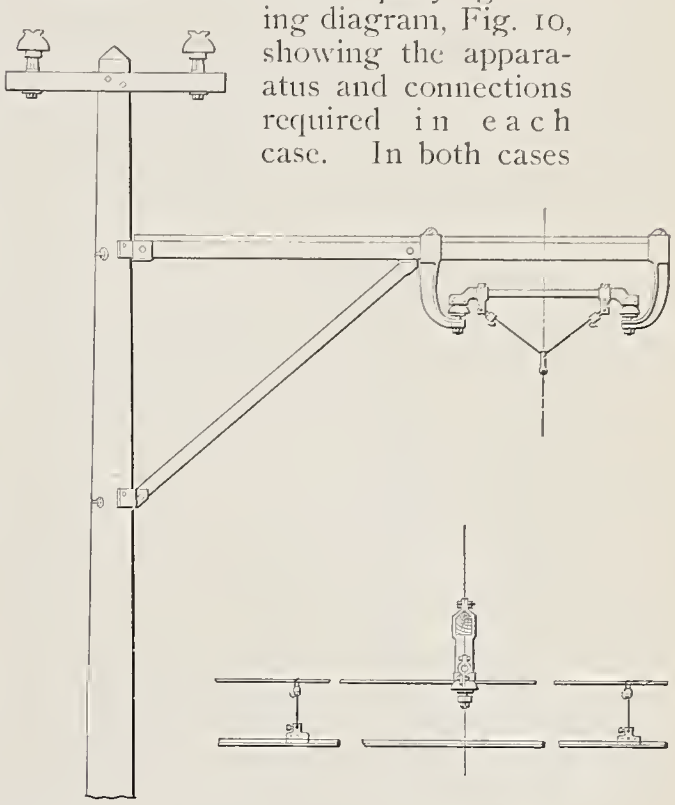


FIG. 8.—AN EXAMPLE OF TROLLEY WIRE SUSPENSION

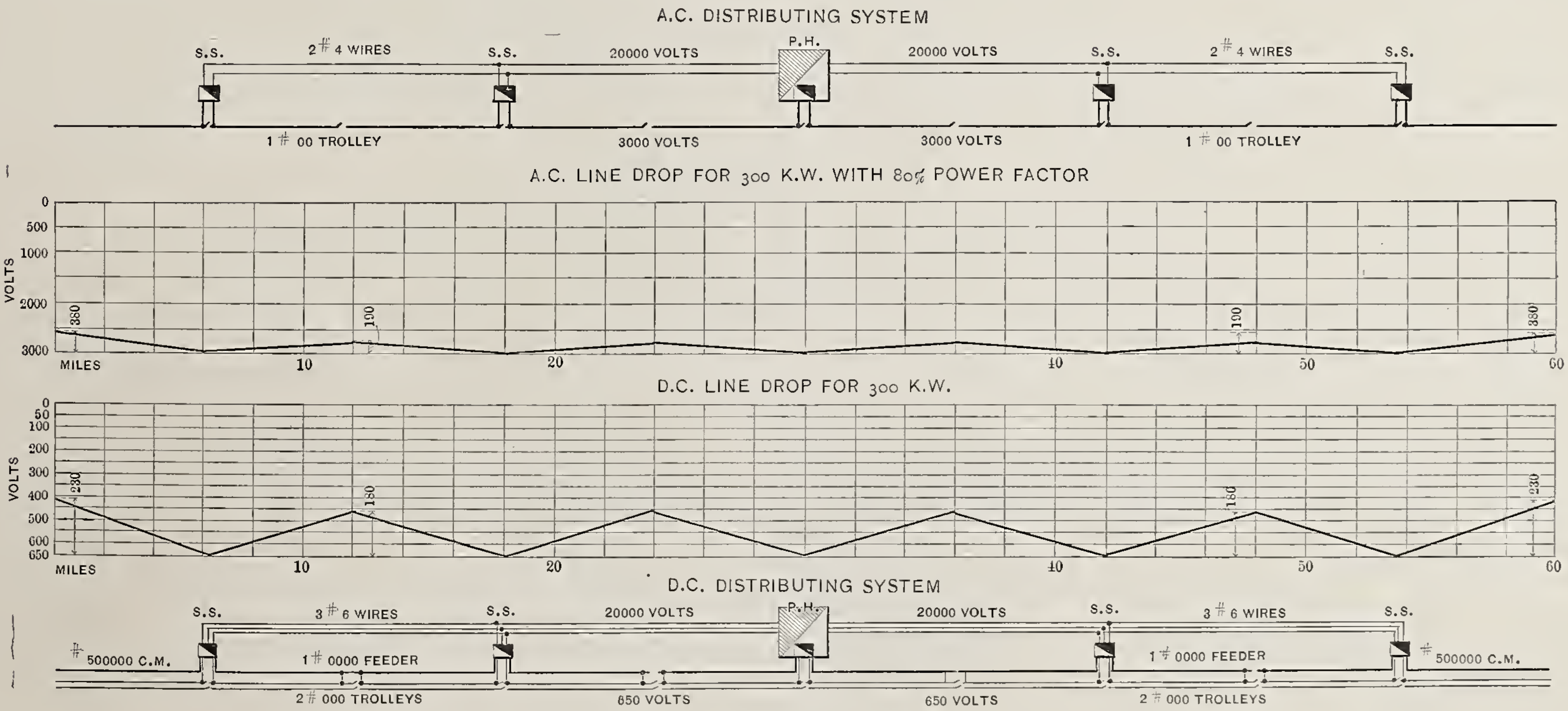


FIG. 9.—DIAGRAMS FOR A 60-MILE ROAD FOR ALTERNATING AND DIRECT CURRENT SYSTEMS

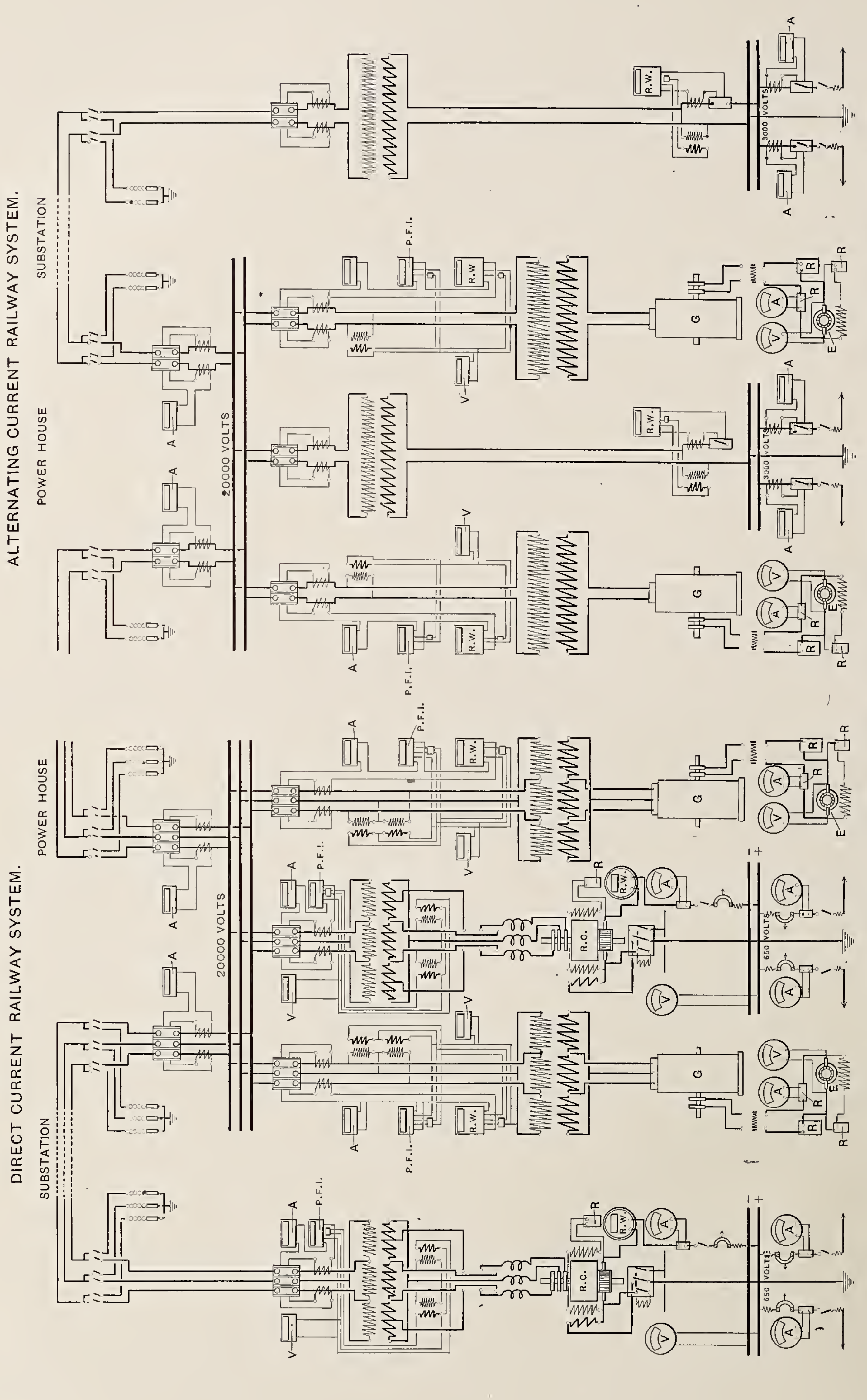
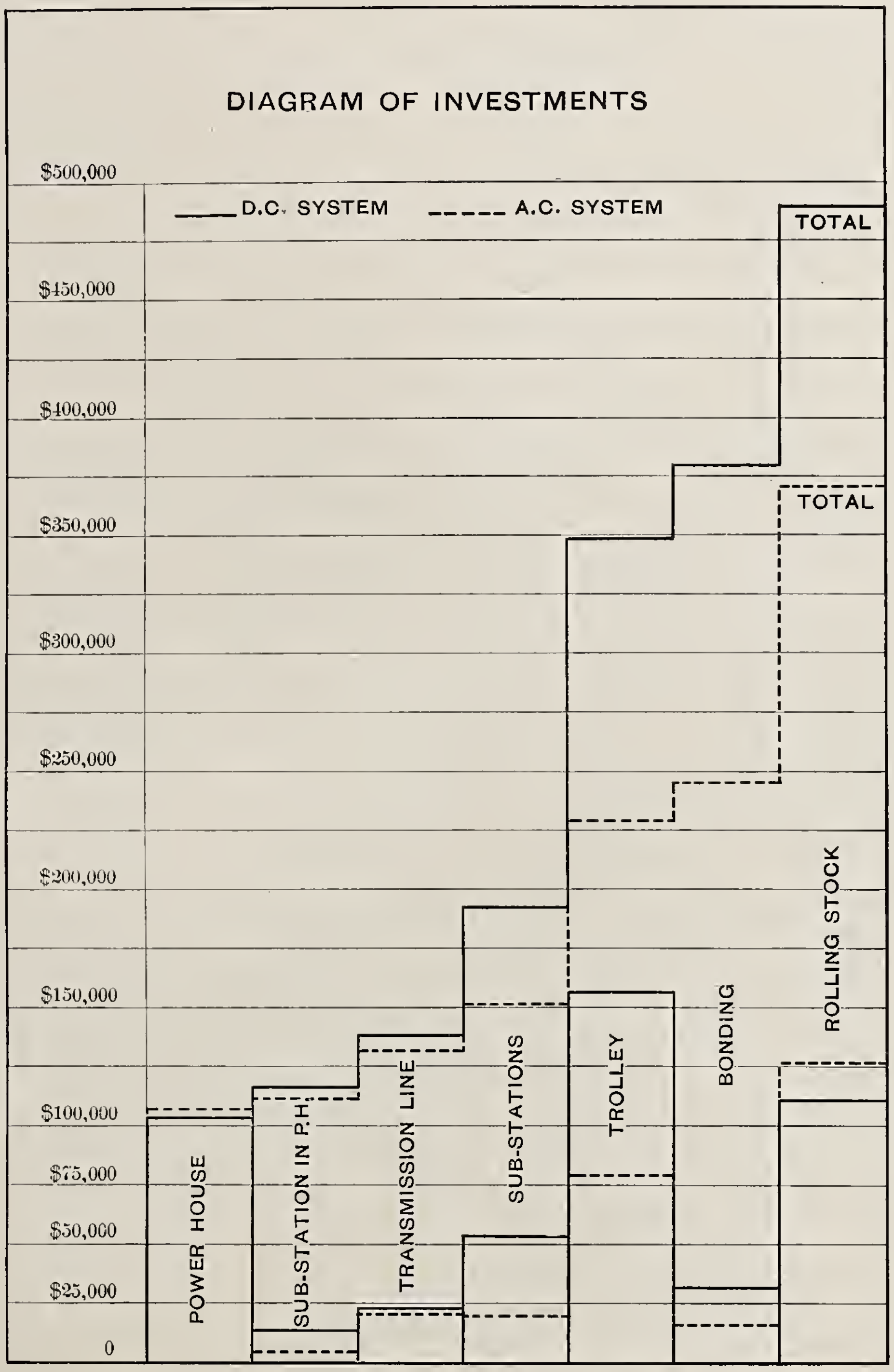


FIG 10.—WIRING DIAGRAM, SHOWING CONNECTIONS AND APPARATUS REQUIRED FOR A DIRECT-CURRENT AND AN ALTERNATING-CURRENT SYSTEM

lines of the direct-connected railroad system three No. 6 wires are assumed, and for the single-phase transmission line two No. 4 wires, costing respectively $10,000 and $11,500.

The proportions of the distributing system have been worked out along the following lines:—For the direct-currect system it was assumed the maximum drop of a car starting at its maximum distance from sub-station should be approximately 200



volts, or about 30 per cent. This will be accomplished by installing two No. 000 trolleys and No. 0000 feeder capacity between sub-stations and 500,000 circular mils feeder for the sub ends. The cost of the copper under these conditions will be about $95,000.

For the alternating-current system the size of the trolley has been determined rather from mechanical than from electrical considerations. A No. 00 grooved trolley has been assumed installed throughout the length of the line, since for this class of service it is not practical to use smaller sizes. The cost of the copper in this case will be $21,500.

In determining the drop for this system 80 per cent power factor has been assumed, and it will be noted that the maximum drop under the same conditions as above mentioned will be 190 volts between sub-stations, or 6.25 per cent, and 380 volts on sub ends, or 12.5 per cent., showing a very considerable advantage in favor of this system. As to the motor equipment in the two systems, at present the alternating-current motor weighs somewhat more than the direct-current motor and operates at a slightly lower efficiency. However, the smaller efficiency of the alternating-current motor is more than counterbalanced by the small percentage loss in the alternating-current distributing system. And, furthermore, with the rapid development now taking place in the alternating-current motor, it is safe to assume that in the very near future its characteristics as to weight and efficiency will soon equal those of the direct-current motor, thus making the advantage of the alternating-current railroad system still more evident.

An idea of the relative investments for the two systems may be best obtained by arranging in parallel columns the cost of the various items, as is done below in the table and accompanying diagram:—

ESTIMATED COST OF THE ELECTRICAL EQUIPMENT OF A 60-MILE, SINGLE-TRACK INTERURBAN RAILROAD

	D. C. System	A. C. System
Power House		
Building	$10,000	$10,000
Foundations	2,500	2,500
Boilers and settings	12,000	12,000
Steam piping and covering	7,500	7,500
Engines	22,000	22,000
Generators, two 400 K. W.	18,000	23,000
Exciters	1,000	1,000
Step-up transformers, 800 K. W.	8,000	7,500
Switchboard	3,500	3,000
Wiring	3,000	2,500
Feed-water heater	800	800
Pumps	800	800
Coal storage	1,000	1,000
Smokestack and flues	2,000	2,000
Fuel economizers	3,000	3,000
Stokers	3,500	3,500
Incidentals	4,400	4,400
Total	$103,000	$106,500
Sub-station in Power House	D. C.	A. C.
Building extension	$1,000	$600
Rotary converter, 300 K. W.	4,800	....
Transformer, 300 K. W.; 200 K. W. A. C.	3,200	2,000
Switchboard	2,000	1,300
Wiring	1,000	500
Incidentals	600	200
Totals	$12,600	$4,600
48 miles Transmission Line	D. C.	A. C.
Poles charged to trolley line.	....	....
Copper	$10,000	$11,500
Insulators, pins and cross-arms	7,500	5,000
Erection	4,000	3,000
Incidentals	1,000	1,000
Totals	$22,500	$20,500
Sub-station Along the Road	D. C.	A. C.
Building	$2,000	$1,000
Rotary converter	4,800	....
Step-down transformers	3,200	2,000
Switchboard	2,000	1,300
Wiring	1,000	500
Incidentals	500	200
Totals	$13,500	$5,000
Four sub-stations	$54,000	$20,000
Trolley Line and Fecder		
Poles, 3,500	$17,500	$17,500
Poles distributed and set	4,000	4,000
Guys and anchors	2,000	2,000
Brackets with hangers	18,000	25,000
Copper, D. C.		
Feeder, 12 miles, 500,000 C.M.		
Feeder, 48 miles, No. 0000		
Trolley, 120 miles, No. 000	95,000	....
A. C.		
Trolley, 60 miles No. 00	....	21,500
Feeder insulators	2,000	....
Erection	10,000	4,000
Incidentals	7,500	4,000
Totals	$156,000	$78,000
Bonding of Rails	D. C.	A. C.
Both rails bonded	$30,000	....
One rail bonded	....	$15,000
Cross bonds	2,000	1,000
Totals	$32,000	$16,000
Rolling Stock		
Ten vestibuled passenger cars, each equipped with four motors and weighing about 30 tons	$75,000	$85,000
Two express passenger cars, equipped with four motors and weighing about 35 tons	18,000	20,500
Two baggage cars, each equipped with four motors and weighing about 30 tons	10,000	12,000
Snow-plow and construction car	7,000	8,500
Totals	$110,000	$126,000

RECAPITULATION

Power house	$103,000	$106,500
Sub-station in power house.	12,600	4,600
Transmission line	22,500	20,500
Sub-stations	54,000	20,000
Trolley line and feeder	156,000	78,000
Bonding	32,000	16,000
Rolling stock	110,000	126,000
Totals	$490,100	$371,600

Cost per mile D. C. system ....$490,100/60 = $8,168
Cost per mile A. C. system ....$371,600/60 = 6,193

$1,955

The decrease of A. C. cost in terms of D. C. investment, 25 per cent.

The increase of D. C. cost in terms of A. C. investment, 32 per cent.

It is not necessary to take up in detail all the items, as they speak for themselves, but it may be of interest to note some items in which the costs vary more widely. The single-phase generators, as would be expected, cost nearly 30 per cent. more than the three-phase generators, amounting to $5000. Small savings on switchboard and wiring reduce the total for the power house $3500 in favor of the direct-current system.

For the sub-station in the power house, principally on account of saving in converter and transformer capacity, the balance is $8000 in favor of the alternating-current system.

The transmission systems are approximately the same, there being $2000 in favor of the alternating-current system.

In the alternating-current distributing system, while the suspension of the trolley is noticeably more expensive than in the direct-current system, on account of special insulators, the immense saving in copper gives a balance of $78,000 in favor of the alternating-current system.

The necessity of bonding but one rail effects a saving of $16,000 in favor of the alternating-current system.

A very liberal allowance has been made by placing the cost of the alternating-current motor equipments one-third in excess of that of the direct-current motor equipment; this, as above noted, is the present cost of alternating-current equipment, and without doubt in the near future this difference will be greatly reduced.

The sum total of the investment for the direct-current system under the assumed conditions is $490,100, while that of the alternating-current system is $371,600. Reducing this to the cost per mile, it is found that the electrical equipment complete amounts to $8168 for the direct-current system and $6193 for the alternating-current system, or a saving of $1955 per mile in favor of the latter.

Expressed in percentage, this means that the alternating-current system effects a saving of 25 per cent. of the cost of the direct-current system, or to state the relation in other words, the cost of the direct-current system is 32 per cent. more than the cost of the alternating-current system,—a showing most favorable for the latter, and this, indeed, during the first year that this apparatus has been on the market.

With the alternating-current motor thus far perfected and the large number of propositions whose realization is conditioned by the cheaper electrical equipment, nothing can hinder the very wide adoption of this system.

The Testing of Transformer Oil

THE usefulness of an oil as an insulation material is not determined by measurements of its insulation resistance, says the "Zeitschrift für Elektrotechnik," but by measurements of the voltage required to break down a given thickness.

A pair of polished balls are supported at a fixed distance below the surface in a vessel containing about 200 cubic centimeters and having a diameter about 3 centimeters. The presence of water or air-bubbles or small fibers greatly affects the results obtained. For the purpose of determining the flashing point of the oil, a weighed quantity of it is heated for about twelve hours in a water bath at 100 degrees C., and the amount evaporated noted. The point at which steam commences ought to be as high as possible, as the flashing point occurs at about the same temperature.

The effect of water is so important that the presence of only 0.06 of 1 per cent. reduces the breakdown voltage by half. Further additions of water have little effect. The presence of water may be qualitatively determined by adding a little cupric sulphate to the oil. When free from water this sulphate is pure white, but becomes blue in contact with water.

A good transformer oil may be distinguished by the following properties:—(1) It ought to be a pure mineral oil obtained from crude petroleum by fractional distillation without chemical treatment; (2) the flash-point ought not to be below 180 degrees C., and the oil ought not to burn steadily under 200 degrees C.; (3) the oil ought to be free from alkalies, moisture or acids; (4) after being heated for eight hours the evaporation ought not to exceed 0.2 of 1 per cent.; (5) the oil ought to be as fluid as possible and a light-yellow color.

A report on the available water power of Russia, made to the recent Russian Electrical Congress, makes an estimate of 11,000,000 horse-power, of which 3,000,000 is included within the borders of Finland.

Electric and Other Street Railways in the United States and Canada

TABLES setting forth the progress in electric street traction in the United States and Canada, have recently been issued by "American Street Railway Investments." These tables compare electric lines with steam, cable and horse, and the progress recorded is very encouraging.

In the United States there are 1187 electric roads, representing a route mileage of 29,212 and over 70,000 cars. Compared with this the cable and steam lines have together a track mileage of 358 and 4839 cars of all classes, including locomotives, the horse lines being well in the rear with 260 miles and 1165 cars. The total for all classes of street railways is 29,830 track miles, and 76,186 cars.

In Canada the figures are not so startling as might be expected. There are forty-two electric roads with a track mileage of 830, and 2416 cars of all classes (motor, trailer and service). The cable and steam roads are disproportionately numerous, there being a track mileage of sixty, with eighty-eight cars and locomotives. The cable and steam lines have almost doubled their track mileage, but (if the figures are correct) the rolling-stock has been reduced about 11 per cent. and the locomotives by almost 50 per cent. There are no records of any horse cars in Canada.

Comparing the records of electric railways of the various groups of American States, some interesting figures result. In the Central States the most marked advance is noticed. Here there are 314 lines in thirteen States, and during 1902-03, the track mileage has been increased from 9533 to 11,073, and the motor cars from 16,654 to 18,524.

The eight Eastern States, which include New York, show a lower track mileage than the Central, but their rolling-stock is much more numerous. The nine Southern States are at the bottom of the electric list, but they are slowly increasing their mileage and their cars. The fourteen Western States show the greatest number of steam and cable lines, and the Eastern group, of horse car lines.

A story is told of a Scotch farmer, who journeyed to London on a visit, and, on returning home, was asked how he had enjoyed himself and how he liked the metropolis. "Mon, I liket it fine, but I couldna' sleep, the light was burning a' nicht." "Could ye no blaw't oot?" his friend inquired. "No mon; ye canna do that noo; they keep it in wee gless bottles!"

Fuel Economy in Electric Station Steam Plants

From the Chemist's Point of View

By JOHN B. C. KERSHAW, F. I. C.

FOR the purpose of discussing the fuel economies which, as a chemist, the writer believes to be attainable in connection with the raising of steam in large electric plants, he will divide the subject into three sections:—

1—The supplies of fuel and water; 2—The combustion of the fuel in the boiler furnace; and 3—The waste gases from combustion.

FUEL SUPPLY

When the chemist regards the conditions under which the manager in charge of a large steam generating plant arranges his contracts for thousands of tons of fuel, to be delivered over a period of some months, he must be struck by the absence of any effective means for checking the quality of the deliveries of the selected fuel. Fuel appears to be the only raw material of which the sale is conducted by what may fairly be called rule-of-thumb methods in place of scientifically exact tests.

Steam-raising trials are generally made with sample wagons of various fuels before the contract is signed, and the selection is based upon the results obtained in these trials. Here, at the very basis of the system of selection, there is wide scope for uncertainty and error. The comparative wetness or dryness of the fuel as it is discharged into the boiler house; the humidity and temperature of the atmosphere and the direction of the wind, all causes which influence the pull of the chimney—the state of the boiler as regards scale; and, finally, the skill and reliability of the fireman, all are factors which have great influence upon the results obtained in the steam-raising trials. The reliability of the fireman is probably the most important factor, though many engineers do not appreciate this. Even where mechanical stokers are employed, the fireman in charge has much influence on the results obtained. In these days of secret gifts and commissions to men in nearly all positions, a small present to a fireman or to the engineer of a boiler plant is by many considered no offense. But such a present, if accepted, would most certainly influence the results obtained in such practical trials of various fuels for the purpose of placing a large coal contract. Are not engineers a little too trustful of human nature in this matter, and would it not be advisable to have some counter-check upon the results of steam-raising trials of fuels under the boilers? The writer then recommends—not that such practical trials should be dispensed with, but that a thoroughly reliable sample of the fuel used for each steam-raising test should be submitted to chemical and calorific examination, and that the results obtained in the trials under the boilers should be judged in the light of these laboratory results. If striking discrepancies should be revealed, the practical trials could be repeated with other men in charge.

The unreliability of the results obtained in many of the so-called "practical" steam-raising trials is proved by the following extracts from one of the recent reports to the Manchester Steam Users' Association by Mr. C. E. Stromeyer, its chief engineer:—

"On examining the trials summarized in the late Mr. Bryan Donkin's work on the 'Heat Efficiency of Steam Boilers,' it was found that whereas the results obtained by different experimenters on one boiler installation agree fairly well, the results obtained at other installations of exactly the same type of boiler are most erratic and even conflicting.

"Thus, if we confine ourselves to Lancashire boilers, of which about 150 tests are recorded, we find enormous variations in the efficiency of boilers worked under practically identical conditions. For instance, in two cases of hand-fired Lancashire boilers, No. 7 and No. 57 in Mr. B. Donkin's book, both burning English coal, the former at the rate of only 13.81 pounds of coal per square foot of grate, against 16.5 in the latter case, and evaporating only 3 pounds of water per square foot of surface against 5.61 pounds, we yet find that the efficiency of the lightly-worked boiler No. 7 is only 53.7 per cent., against 71.6 per cent. in the case of No. 57, the hard-worked boiler. Again, comparing the two other tests, No. 12 and No. 67, we find the hard-worked boiler to be the more inefficient of the two, the performances being in the ratios of 53.2 and 74.8.

"Evidently these anomalies depended either on the experimenters, or on the conditions of firing. The recorded trials were, therefore, subjected to a careful analysis, and those in which the experimenters might be considered at fault, or in which their data were incomplete, were rejected. By this means the total number of about 340 boilers of customary types was reduced to a very few, more especially as, when making calculations, it was found that the data must have been incorrect, some boilers appearing to have received heat from outside instead of losing some by radiation."

The writer would recommend, for practical purposes, the "approximate" rather than the "elementary" analysis of fuels. The former gives the percentage of moisture, coke, volatile matters, fixed carbon and ash. The latter yields the percentage of the various elements which are contained in the fuel, namely, oxygen, hydrogen, nitrogen and carbon. For the guidance of the boiler engineer, it is much more useful to know that a fuel contains, say, 29 per cent. of volatile hydrocarbons, 13 per cent. ash, and 58 per cent. fixed carbon, than to be informed that it contains 72 per cent. *C*, 4.8 per cent. *H*, 7.2 per cent. *O*, and 0.71 per cent. *N*.

Recently a formula was published by Goutel, which permits the calorific value to be calculated from the results obtained by this "approximate" analysis; and, therefore, one of the arguments for carrying out the troublesome and extensive elementary analysis of fuel—namely, that it enabled one to calculate calorific values with accuracy—has lost weight.

In the writer's opinion, such approximate analysis of fuel ought always to be made in conjunction with practical steam-raising trials, and in the decision as to the choice of fuel, the laboratory results ought to have due weight. A further advantage of having the exact figures of the laboratory trials of the fuel for reference is, that a check upon the deliveries of fuel during the time for which the contract is running can be easily kept. At

weekly, fortnightly or monthly intervals, reliable samples of the fuel should be taken and submitted to the approximate analysis and laboratory calorimetric tests.

Any variation in the quality of the fuel should at once be reported, and the fact that such examination of their deliveries at the boilers was being periodically made would have undoubted effect upon the firm fulfilling the fuel contract and upon the colliery managers. It is not generally recognized that one colliery often supplies five or six varieties and qualities of coal from the different seams worked, with ash contents varying from 6 per cent. up to 20 per cent. The writer knows one such example.

At times accidentally, and at times possibly intentionally, buyers may be provided with a fuel much inferior to that for which they had contracted. Unless the fireman complains, nothing is known or said about this deterioration; and, as already remarked, the fireman may have some interest in keeping quiet.

Coal seams also become worked out in time, and such an incident may occur during the delivery of a contract. Hence the importance of instituting some scientific and systematic check upon the quality of the fuel deliveries.

It may be urged that periodic steam-raising trials are sufficient. But apart from the unreliability, already referred to, of the results obtained in such trials, as guides to the quality of the fuel actually being delivered, there is the question of trouble and expense involved in conducting them. On the ground of expense alone the laboratory examination of carefully taken samples is to be preferred.

The chemical examination of fuel is regularly carried out in the laboratories of most railway companies and of large industrial establishments, and engineers of important steam plants everywhere would be wise to follow the same plan. If their consumption is not large enough to warrant the engagement of an analytical chemist and the equipment of a laboratory for this work, they might with advantage send their samples of fuel to one of the numerous chemists who specialize in this class of work. The analysis of fuel and the determination of its calorific value are not work of a very simple character, and the writer does not recommend engineers to attempt it themselves.

Even in the matter of sampling, much care and attention are required if the weight of fuel to be sampled is large and the sample is to be a thoroughly representative one. The notion of many engineers that a shovelful of fuel, selected hap-hazard and placed in a box, is a sample, is a most misleading one.

WATER SUPPLY

Most engineers are now ready to recognize the value of analyses of boiler waters. It is, therefore, not necessary to discuss this point at any great length. Where the hardness of water used for feeding the boilers is above 15 English degrees, equivalent, that is, to 15 grains of calcium carbonate per gallon of water, some form of water-softening apparatus ought to be used. It is indeed questionable whether such an installation would not also prove remunerative in large power stations even when the water employed is above this standard of purity.

Lime and carbonate of soda or caustic soda are the usual chemicals used for water-softening. The amount of these which it is necessary to employ can be determined only by chemical examination of the feed-water. It is customary to base this calculation upon the results of one analysis only; but the examination should be repeated at quarterly or shorter intervals, for the character of the water supply may change, and the appearance of a water is no guide to its chemical constituents.

Calcium carbonate and sulphate, and the corresponding magnesium salts, are all held in solution in water, and may increase greatly in amount, without any change in the water visible to the eye. Water drawn from brooks or rivers in the vicinity of the coast may also, at the times of flood or spring tide, become contaminated with much ordinary salt, which should not be permitted to collect in any large amount inside boilers, since it leads to pitting and corrosion. Here, again, no change in the water can be detected by the eye, and only chemical analysis will reveal the presence of this impurity in excessive amount.

THE COMBUSTION OF THE FUEL

Coal may, for practical purposes, be regarded as a mixture of solid carbon and volatile hydrocarbons, with moisture and ash as impurities. Engineers have not sufficiently recognized the combustion difficulties due to the high percentage of volatile matters present in many fuels, or the need for large combustion chambers to obtain perfect combustion in such cases.

The perfect and economic combustion of bituminous coal demands conditions which are not often met with in the modern boiler plant. These conditions are:—

1. A sufficiency of air, but not an excess.

2. A sufficiently high temperature in the combustion chamber.

3. A perfect mixture of the air and volatile hydrocarbons.

The first and second of these conditions are not always fulfilled in the ordinary working of boilers. The third condition is seldom recognized as essential, and where it is attained it is more the result of chance than of design.

The supply of air to the boiler furnace is, of course, controlled by the fireman; and the tendency, where no chemical examination of the flue gases is made, especially in large towns, is to work boiler fires with a large excess, as it is more easy to get over the smoke difficulty in this way. But excess of air means waste of heat in the chimney gases, since every pound of these gases carries off a definite amount of heat from the furnace, and the use of economizers does not entirely obviate this loss. With the exit gases at a temperature of 600 Fahr., the losses due to excess air may vary from 13 to 68 per cent. of the fuel burned. The latter loss is that represented by only 3 per cent. of carbonic acid in the waste gases, and is, of course, exceptional. But the writer has many times found only 7 to 8 per cent. of carbonic acid in the waste gases from modern boiler plants and this shows a fuel loss of about 25 per cent.

With careful firing and correct draught an average of 14 per cent. of carbonic acid should be present in the chimney gases. The ordinary percentage is far below this figure, and some authorities place the general average at only 8 per cent. This low percentage is due to excessive draught, and consequent unnecessary amount of air passing through the boiler flues. The result is a large increase in the amount of heat carried away by the waste gases. The actual loss, represented by the difference between 14 per cent. and 8 per cent. of carbonic acid in the waste gases, with chimney gases at 560 degrees Fahr., is equal to 10 per cent. of the fuel burned in the boilers.

As regards working boiler furnaces with too little air, and thus producing carbonic oxide in place of carbonic acid, with consequent loss of heating effect, this danger is minimized by the fact that, with the cheaper forms of fuel, smoke is always produced when the air supply is insufficient, and the fireman has thus a visible check upon his work.

It would, however, be of advantage if engineers in charge of boiler plants would always arrange it so that firemen could see the chimney top without going outside the boiler house. When the plan of building construction is

such that a direct view of the chimney is obstructed, reflecting mirrors can be used at one or two points to attain the desired end. Dampers that are in good working order, and that can be opened or closed by the fireman without leaving the firing plate of the boiler, are also essential adjuncts for the proper regulation of the air supply, for with bituminous fuels the amount of air required for perfect combustion varies greatly at the different stages of the process. An enormous volume of gas is liberated within the furnace of a boiler within a few minutes of firing when fresh fuel of this character is charged on to the red-hot layer of coke lying upon the grate bars.

A new instrument for registering the draught in the furnace, and before the damper, called the pyrometer, has been placed on the market, and it is possible that the use of this by boiler engineers would also conduce to more efficient regulation of the air supply to the boiler fires. The instrument resembles an ordinary steam pressure gauge in appearance, and an intelligent fireman would soon learn how to use it with advantage. Rule-of-thumb methods in the matter of air supply to boiler fires should certainly be displaced. The problem when burning bituminous fuels is much less simple than the ordinary fireman realizes; and, as already pointed out, fuel losses than can rise to 15 or 20 per cent. may result from this one cause alone.

As regards the second condition of perfect combustion, namely, the maintenance of a sufficiently high temperature in the combustion chamber, this is absolutely essential in the burning of fuels containing 10 per cent. or more of volatile hydrocarbons, and it may be ignored only when using coke or anthracite fuels. Unfortunately, boiler engineers have not generally recognized this condition in the construction of setting of boilers, and nine-tenths of the factory smoke produced may be ascribed to the failure to maintain proper furnace temperature. The water-tube boiler makers are the chief offenders in this respect. In most of their boilers, as at present constructed and set, perfect combustion of the fuel can be obtained only when using anthracite coal. When ordinary bituminous fuels are used in such boilers, the volatile hydrocarbons which distill from the grate, even when mixed with a sufficiency of air, are brought too quickly into contact with the boiler tubes, and the temperature of the gases is thus greatly reduced before perfect combustion has had time to take place.

It is not sufficient to have a mixture of the inflammable gases and air for perfect combustion to ensue. These gases must not only be mixed, but they must also be maintained at or about a temperature known as the combustion temperature. This temperature for the hydrocarbons distilled from coal is given by different observers as between about 940 and 1200 degrees Fahr. The obvious method of obtaining this temperature is to provide a combustion chamber lined with some refractory and non-conducting material which will not allow heat to be dissipated before perfect combustion of the gases has occurred. Badly designed boilers may be made suitable for burning bituminous fuels without any very great capital outlay, and good results have been obtained with such modified forms of setting.

It may here be pointed out, too, that the evaporative efficiency of a boiler is increased by obtaining the highest possible initial temperature in the combustion process. According to Mr. Stromeyer, the heat transmission between the water and the hot gases is directly proportional to the difference of temperature between them, and, therefore, this transmission is higher the greater this difference. In connection with stationary boilers, no serious attempt has yet been made to increase the temperature of the combustion process by heating the air used in the boiler furnace, but some progress has been made in this direction in the design of marine boilers.

When one notes the remarkable results and high thermal efficiencies obtained with the regenerative principle applied to glass furnaces, one is tempted to ask whether some of the heat permitted to escape with the waste gases from stationary boiler plants could not be utilized in this way, and the writer is of opinion that this subject is well worth attention.

Turning now to the third condition for perfect combustion, namely, perfect mixture of the air and volatile hydrocarbons, we find the condition is imperfectly provided for in the ordinary boiler furnace when burning bituminous fuels. The mere opening by the fireman of the slide in the furnace doors will provide neither the amount of air nor the admixture requisite for burning the great volume of volatile hydrocarbons given off immediately after charging fresh fuel. Nevertheless, this is the only provision made in the ordinary types of boiler furnace.

A supply of air, perfectly heated, coming in behind the bridge or at the rear of the fire-grate is also necessary in order to obtain perfect combustion, and this air must be distributed over the width of the furnace in order to provide all portions of the mass of volatile hydrocarbons with the oxygen necessary for their thorough combustion. A secondary combustion chamber, walled with non-conducting material, is also necessary, in order to guard against loss of temperature, before the combustion of these volatile gases is completed. The higher the percentage of volatile hydrocarbons in the fuel, the larger will be the space required for the perfect mixture and combustion of these products. Neglect to provide for the combustion of these volatile hydrocarbons has led to the invention of a number of smoke prevention appliances (some good and some bad), which would have been utterly uncalled for had a little more knowledge of chemical science been included in the education of boiler engineers.

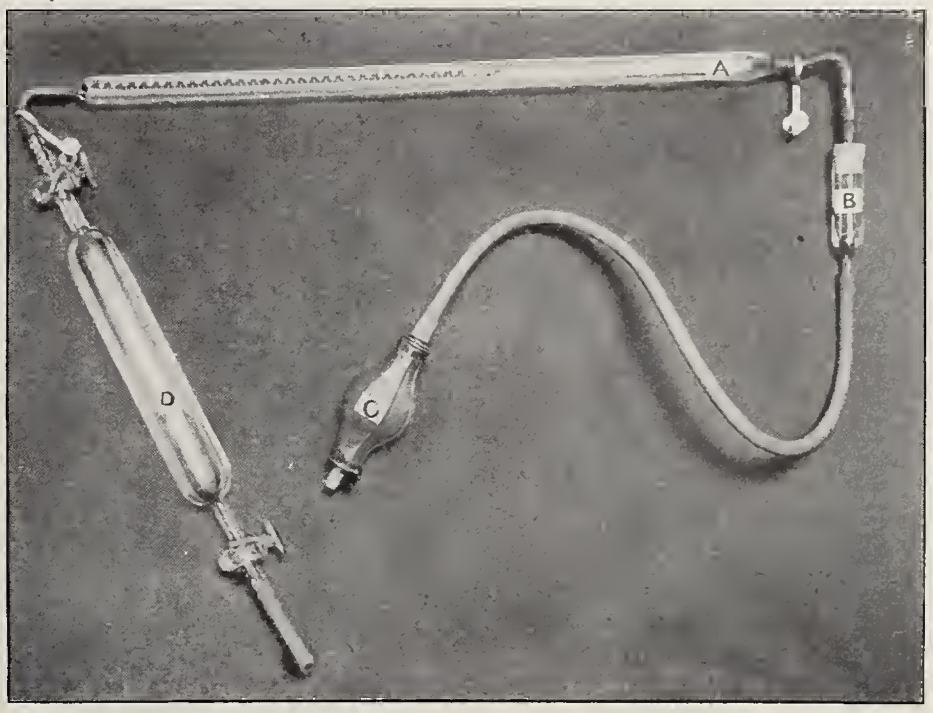


FIG. 1.—FLUE GAS SAMPLING APPARATUS

THE WASTE GASES OF COMBUSTION

From what has already been said, it will be gathered that the regular and systematic examination of the waste gases from boiler furnaces is absolutely necessary for the attainment of the highest possible efficiency with the fuel used. Such examination should include the temperature of the exit gases, the draught behind the dampers and the chemical constituents of the gases. At present, the plants where such systematic examination is carried out are comparatively rare.

As regards the temperature determinations, these may be made either with electrical resistance pyrometers of the Chatelier type, or with special high-temperature mercury thermometers, reading up to over 1000 degrees Fahr. These thermometers are made of glass of special quality, and are filled with nitrogen, under pressure, above the mercury.

A recording form of resistance pyrometer has also been placed on the market, affording a continuous record of the temperature of the exit flue gases, with little or no expenditure of time on the part of the engineer in charge. For works' use a water pyrometer also is of some advantage, more especially for determining roughly the temperatures in places where a mercury thermometer could not be safely employed, or for determining temperatures much above the limit permissible with such a thermometer.

A simple form of water pyrometer consists of a small block of iron held in some suitable form of carrier by which it can be suspended in the flue where the temperature is to be ascertained. When the iron block has been exposed long enough to make it reasonably certain that it has acquired the flue temperature, it is immersed in a known weight of water of a certain temperature in a special receptacle, and the increase in temperature of the water is noted. With the weights of the iron block and of the water receptacle known, and the other data just mentioned at hand, the temperature of the iron block, or, in other words, the temperature of the flue gases, can be easily calculated.

For the measurement of the draught, an ordinary water-gauge may be used, or the instrument known as the pyrometer, already referred to, may be employed. Many failures to obtain perfect combustion in boiler furnaces are due to insufficient draught.

The chemical constitution of the exit flue gases may be ascertained with various forms of apparatus; but none of these will yield valuable results unless considerable thought, care and attention are given to the sampling of the gases. An opening for drawing samples ought to be left at the time of setting, in the top or side flue-walls of each boiler, at the point where the boiler exit flue joins the main flue to the chimney. A 30-inch length of wrought iron pipe, about $1\frac{3}{4}$ inches in diameter, with a flanged top, should be set with fire-clay in this hole, and cotton waste or an iron plug should be used to close the end opening to the air. When a sample of flue gases is required, such a sampling hole is always ready for use, and valuable time is not wasted in looking for the place or in clearing the accumulated rubbish from the hole when found.

The use of a large aspirator containing water cannot be recommended for collecting an average sample of gases over long periods, as carbonic acid gas is slightly soluble in water, and the absorption with a sample of gases, containing 8 per cent. or more of carbonic acid, is noticeable in a few hours. The author would recommend a series of snap samples taken at short intervals of time. The average test of these samples gives a reliable check upon the work of the boiler and fireman. The best apparatus for taking such snap samples is a rubber finger pump, provided with a simple form of stop-valve for preventing any leakage of air past the valves of the pump, which are never perfectly tight.

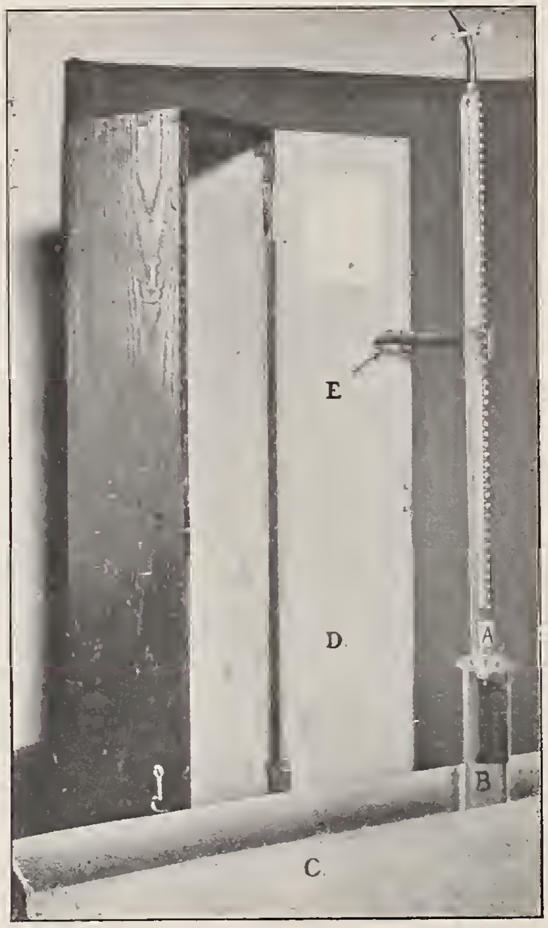


FIG. 2.—A CARBONIC ACID TESTING APPARATUS FOR WORKS' USE

Fig. 1 shows such a gas-sampling apparatus connected to two sample tubes. *C* is the rubber finger-pump, holding about 35 cc; *B* is the rubber stop-valve, which permits the gas to pass only from *A* to *C*; *A* is a Honigman gas-burette; and *D* is a gas-sample tube for preserving a check sample of the gas.

The sample of gas is obtained in these tubes by the dry method, five times the volume of gas being pumped through, by aid of *C*, so as to remove all the air originally present. For the apparatus shown, 5 (220 + 100 cc) = 1600 cc is required and 46 compressions of *C* will effect this displacement of air and gas. A period of about two minutes will, therefore, suffice to obtain a reliable sample of the flue gases with this apparatus.

The sample of gas obtained in this way can be kept for many hours without suffering any change, since the amount of moisture which condenses on the interior walls of the glass sample tube is not sufficient to absorb any material volume of carbonic acid. A sample tube provided with glass stopcocks, *D*, must, however, be employed if the sample of gas is to be preserved some time before analysis. If it be examined at once, a tube closed with rubber and ordinary spring clips, *A*, may be employed with safety.

The complete examination of flue gases for carbonic acid, carbonic oxide and oxygen is most conveniently carried out in the Orsat-Lunge form of gas-testing apparatus. Several forms of recording carbonic acid apparatus have also been invented and are in successful use. They yield valuable information, but require careful attention, and the results require checking by independent tests at intervals of three or four weeks.

For works' use, the writer has designed a form of apparatus which he considers will yield valuable results in the hands of intelligent engineers in charge of boiler plants. This is illustrated in Fig. 2. *A* is a Honigman gas-burette, holding 100 cc; *B* is a cylindrical glass jar, 8 inches high and 2 inches in diameter; *C* is a zinc trough holding water; *E* is a spring-clamp, and *D* is the box which serves to contain all the apparatus when not being utilized as a burette stand, as shown in the illustration.

The gas to be tested for carbonic acid is collected by the dry method in *A*, and 100 cc are accurately measured by removing the clip from the rubber at the lower end of *A*, fixing the burette in *E*, as shown, and adjusting the level of water in the jar, *B*. Carbonic acid absorption is next effected by slipping into *A*, by the wider end, a small piece of solid caustic potash specially prepared for this use. The burette, *A*, is then removed from *E*,

the end is closed with a glass rod, and the caustic potash is dissolved by gentle agitation. Two minutes suffice to dissolve the solid caustic and to absorb the carbonic acid in *A*, and after immersion of *A*, in the water in the trough, *C*, to bring the contents of the burette to the original temperature, the glass stopper is removed from the lower end of *A*, the burette is again fixed as shown in the illustration, and the reduction in gas volume is ascertained. This gives at once the percentage of carbonic acid in the original gas.

The absence of any liquid, and the compactness of the apparatus when dismounted and packed in its case, are two special points which should recommend it for works' use.

Nuggets from the International Electrical Congress

ONE of the "geological conditions" that has had as much to do with the present extensive development of electric power transmission in California, as high water falls, was the absence of coal in that State.
C. F. Scott.

The leading American manufacturers have already supplied about 1,250,000 K. W. in generators for use in long distance transmission.
C. F. Scott.

In long-distance transmission experience has shown that very high voltages are best for lines over 50 miles in length. Calculations show that the rise in voltage due to surging at break of circuit is 200 times the interrupted current. The higher the voltage, the less this current; consequently the less will be the rise in voltage due to surging. In long-distance transmission the line insulators limit the voltage. *F. G. Baum.*

In long-distance transmission where the system is fed at many points and where it supplies current at many points, artificial regulating devices for compensating for leading currents due to capacity, or for lagging currents due to induction, are unnecessary, because, under the conditions stated, such difficulties disappear.
F. A. C. Perrine.

Only about one-third of the output of the Niagara Falls electric power plant is now used for electric light and power purposes; the remaining two-thirds are used by electro-chemical industries which have been originated since the plant was first designed.
C. F. Scott.

The selection of polyphase current for the Niagara current transmission was undoubtedly an outcome of the successful use of polyphase current transmission on the Tivoli-Rome line.
E. Kilburn Scott.

By combining alternating-current transmission with direct-current distribution in cities, the full advantage of both systems are available, and their disadvantages are avoided.
L. A. Ferguson.

With the modern system of alternating-current generators, high tension transmission and converting substations, it is absolutely essential to use storage batteries as auxiliaries in order to insure continuous service under all conditions. *J. W. Lieb, Jr.*

In central station management the result striven for should be the lowering of power rates to such a degree as to increase the service so that the lighting load shall be small in comparison with the power load.
F. E. Gripper.

The electric light and power companies in England that charge the lowest rates pay the best dividends.
R. E. Crompton.

The fact is sometimes overlooked that the expense for fuel, oil and labor, which varies roughly with the station output, is not the only cost of producing a kilowatt-hour; this cost is in many cases doubled by interest and other fixed charges.
R. Hammond.

The troubles that central station engineers fear most are defects in underground feeders connecting the power house with a sub-station. Such defects should be located as soon as they manifest themselves, not waiting until an actual breakdown occurs.
W. C. L. Eglin.

The sparking method of determining very high voltages which was formerly employed in connection with insulation tests has been abandoned owing to the errors that were found to creep in. *C. E. Skinner.*

Every insulating material has a limit of resistance to puncture. When the maximum pressure per unit of thickness of insulation is exceeded, increasing the thickness will not prevent a break-down, inasmuch as the stress being greatest nearest the conductor, adding additional thickness of insulating material does not reduce proportionately the stress on the inner layer. To obtain the highest resistance to puncture, the insulating material of cables should be applied in layers of graded specifice inductive capacity.
E. Jona.

Where the dielectric strength of oil is impaired by moisture, its standard dielectric strength may be restored by pumping hot air through it.
F. O. Blackwell.

In the construction of transformers a great saving in first cost may be obtained by sacrificing a little of the efficiency. A transformer of 96 per cent. efficiency is obtainable at about one-half the cost of a transformer of equal capacity, but having 99 per cent. efficiency. *F. O. Blackwell.*

To produce a true alternating-current arc stream in mercury vapor, 9000 volts are required; at lower voltages every other half wave is suppressed, and the current is semi-directional. The direction of the current is purely accidental, depending on which half wave the arc stream may happen to start with, but after starting, the current is maintained absolutely uni-directional.
C. P. Steinmetz.

The alternating-current commutating motor will not make great inroads into the field now occupied by the direct-current motor. It will probably develop a new field or will supplant the direct-current motor analogously as the alternating-current system of distribution has supplanted, but has not displaced, the direct current system of distribution first used in cities. *C. P. Steinmetz.*

The alternating-current commutating motor should not be adopted too hastily. This motor has had many of the ailments that afflict motors, and has been dosed until brought into its present condition. A more vital question than the use of alternating current in electric railways is whether electricity should be used on trunk lines. This is a question that can only be settled by the hard and fast rule of necessity. *F. J. Sprague.*

The Pittsburg department of the Weather Bureau has adopted a system of sending out daily local weather forecasts by telephone. In Western Pennsylvania, West Virginia and Eastern Ohio most of the farmers have telephones in their houses and can be reached much quicker by telephone than if the reports were sent by mail.

Gas Engines Versus Electric Motors

By FRED. M. KIMBALL

A Paper Read at the Recent Newcastle (N. H.) Meeting of the Association of Edison Illuminating Companies

THERE are estimated to be about 400 manufacturers of gas and gasoline engines in the United States at the present time. The proportions to which the industry has grown may be judged from the fact that one of the principal manufacturers has, within the last thirty-five years, put out more than 75,000 engines, with a nominal rating of over one-half million horse-power. This company has not made a specialty of large engines, and some of its competitors have probably put out an equal capacity, although made up of a less number of units. The size of the average engine of the type alluded to is 6½ H. P., which shows the apparent applicability of these machines to the requirements of that class of power consumers which electric light stations hope to reach with motor service.

Manufacturers of gas engines have been fully alive to the necessity of conducting an educational campaign. Gas or gasoline engines are to be found in the technical departments of about fifty colleges and technical schools. Their literature has been well written, well illustrated and well distributed. It is attractive, and when printers are advised that the average cost of maintaining each rated horse-power of engine capacity in their establishments will be about $1.80 per month, and tailors, shirt makers and clothing manufacturers are advised that the average cost of maintaining each rated horse-power in their lines of business will be about $2.50 a month, and when factory and store owners and others desiring electric lighting are told that with gasoline at 10 cents per gallon, a gasoline engine may be used for operating a dynamo with an expense of 1-10 of a cent per 16 candle-power lamp, per hour, it is little wonder that the introduction of these engines is making such rapid headway. As a matter of fact, the cost of maintaining a horse-power from an explosive engine varies very greatly, according to the fuel used.

While it is a comparatively easy matter to deal with the subject of gas or gasoline engines from an academic standpoint, if one confines himself to a discussion based on actual financial results which have attended the use of explosive engines as sources of power, he may find considerable difficulty in adducing sufficient arguments of the first order, that will bear the test of close scrutiny, to influence a prospective customer's choice in favor of the motor as against the engine.

While there are actually many definite advantages in the use of an electric motor over the use of a gas engine, and in the term "gas engine" I shall include broadly all explosive engines using gas or vapor of the various hydrocarbons obtained from petroleum, we must admit, to begin with, that the gas engine, as at present improved and constructed, is highly satisfactory in operation in the majority of cases, affords a fairly adequate power supply for most purposes at a very low cost and has many influential friends.

If the prospective purchaser of a power unit be actuated solely by the desire to produce a given amount of power at the least possible direct cost, he can probably obtain it by the employment of some form of gas engine more cheaply than by any other artificial method. Although the claims of the makers of explosive engines as to the quantity of fuel required to afford a given horse-power per hour are usually exceeded in actual practice, yet when fuel only is considered, and notwithstanding the larger amount really consumed, a horse-power may be produced at a very attractive figure.

The actual cost of power, however, is made up not only of the cost of fuel, but by the added cost of attendance, maintenance, repairs, insurance, increment of productive value of floor space required for the prime mover, and value of production lost if the prime mover is periodically out of commission for longer or shorter periods. Even with all this added together, the cost of producing a horse-power with a well-designed and constructed explosive engine may still be on an equality with the cost of producing a horse-power with an electric motor using current from a central station at average prices. In the majority of cases, however, and if total first cost, reliability of operation, convenience and small expense of attendance, low cost of maintenance, freedom from fire risk, regularity of speed, flexibility of application and absence of danger are given due weight, the motor will generally be found more economical.

Taking up a comparison of the salient features of the two prime movers in order, we first note that an explosive engine capable of affording a given horse-power will rarely weigh less than twice as much as a motor giving corresponding output, and in the larger sizes may weigh as much as five times more than a motor giving corresponding output, and the floor space required will be from two to four times as much as that required by the motor.

The table on the next page compares the dimensions of gas engines of standard make with electric motors of standard make.

The weight of accessories, such as piping, gas bags, tanks, foundations for engines, belt tighteners and rheostats for motors, with the space occupied by them, have not been included in the table.

It will be noted that the floor space and weight are materially greater for any gas engine than for the corresponding electric motor. In the double rating of the engines the first is the nominal rating and the second the actual or usable rating. In the case of motors there is only one rating and that is for continuous operation at full load.

In convenience and cost of installation, so far as relates to occupation of productive floor space and freedom from the necessity of providing expensive foundations, the motor is easily superior to the gas engine, for it may be suspended from the ceiling or fastened against the wall, if need be, thereby gaining a very important lead over its rival, which must necessarily be located on the floor and be provided with a very secure foundation if it is to operate in a manner at all satisfactory.

An electric motor may be very quickly installed if the need is urgent.

The wires may be readily run to any location. The gas engine must be placed in a selected location where pipes from both water and gas supplies may be easily brought to it, and, in the case of gasoline engine, where the gasoline tank can be properly located in regard thereto. The expense of piping and other accessories in connection with a gas engine is usually far greater than the expense of wires and their accessories used in connection with a motor.

GAS ENGINES OF THE VERTICAL TYPE, NO. 1

	Cubic Space in Inches	Weight in Pounds	Speed in R. P. M.
2 H. P. gas engine	36,288	900	400
2 H. P. electric motor	9,040	345	1,100
3½ H. P. gas engine	58,320	1,300	360
5 H. P. electric motor	20,463	630	1,100

GAS ENGINES OF THE HORIZONTAL TYPE, NO. 2

	Floor Space in Inches	Weight in Pounds	Speed in R. P. M.
3½-3 H. P. gas engine	2,256	1,400	300
3 H. P. electric motor	615	455	1,100
6-5 H. P. gas engine	2,646	1,800	300
5 H. P. electric motor	714	630	1,100
15-12 H. P. gas engine	5,016	3,500	265
15 H. P. electric motor	1,295	1,240	975
50-45 H. P. gas engine	13,056	13,000	220
50 H. P. electric motor	3,106	4,728	600

GAS ENGINES OF THE HORIZONTAL TYPE, NO. 3

	Floor Space in Inches	Weight in Pounds	Speed in R. P. M.
4½-3½ H. P. gas engine	1,674	2,100	340
3 H. P. electric motor	615	455	1,100
15-12 H. P. gas engine	3,600	4,800	260
15 H. P. electric motor	1,295	1,240	975
60-50 H. P. gas engine	9,792	21,500	230
50 H. P. electric motor	3,105	4,728	600

Purchasers of gas or gasoline engines have often been very much chagrined to find that in the initial price of the engine, alone, they have realized but a comparatively small part of the total expense of a complete and operative installation.

From an insurance standpoint the motor again is superior to the gas engine, and it is only necessary to consult the manuals of the insurance companies to know to what an extent this is true. Under normal conditions there is no spark and only negligible heat about the motor. With a gas engine there must be a hot tube, spark, or its equivalent, and there is at all times present not only an exceedingly inflammable gas or vapor, but, in the case of a gasoline engine, an exceedingly inflammable liquid hydrocarbon of extreme molecular tenuity and therefore difficult to prevent from leaking from pipes, tanks or valves.

If the electricity supplied to a motor fails, the motor will stop without damage to itself. If the water supplied for cooling a gas engine fails, however, the engine may continue in operation to its own ultimate serious damage.

The electric motor is practically noiseless. If it runs at high speed there may be some sound due to windage and possibly a slight magnetic hum. With the explosive engine there is inevitably a considerable noise due to the gas explosion which cannot be entirely muffled. In general, the greater the muffling effect the more inefficient the engine will be.

There is no odor in connection with the motor, while often a most disagreeable odor accompanies the use of the gas engine. It is comparatively easy to keep a motor clean—it is difficult to keep an explosive engine thoroughly clean. There are but two bearings to lubricate on a motor, and they are usually self-oiling. There are many bearings to lubricate on a gas engine, and nearly all of them are of such nature that they cannot be served by an automatic oiling device as simple as that used in the case of the motor.

An electric motor will temporarily carry a heavy overload, but a gas engine will rarely carry any greater load than that for which it is rated. With motor-driven machinery, if exigencies of the occasion require heavy work, the motor will temporarily furnish the necessary power. With a gas engine no more work can be put on the machines operated than the maximum rating of the engine will care for. If it is desired to provide for overloads on gas engine driven plants, then engines of larger than normal capacity must be installed, which, during the greater portion of the time and when operating under ordinary conditions, will be inefficient. Furthermore, capital is needlessly tied up in such an installation.

The electric motor may readily be started without manual labor or loss of time. Practically no preparation is required to put it in motion. The gas engine requires the aid of both manual labor, or its equivalent, the adjustment of several valves and the expenditure of considerable time to put it in motion and adjust it for operation.

The motor may be started under load. The gas engine must, except accessory starting apparatus be installed and used, be started without the load. The use of this accessory apparatus means additional investment of capital, increased space required and augmented maintenance.

The speed of the electric motor may be easily varied if so desired. The gas engine will not permit of such speed variation; therefore, for driving classes of machinery involving the necessity of varying speed, the motor is pre-eminently better fitted than the gas engine.

In the finer varieties of silk spinning, for instance, the lack of angular speed control in the ordinary gas engine practically prohibits its use in that industry.

The motor may be started from a point remote from its location. Not so with the engine. Explosive engines may ordinarily be used only where power is to be distributed through shafting with consequent losses entailed thereby. Motors, on the contrary, may be applied directly to machines and machine tools when a saving in operation or a more advantageous location of the machines or tools will be effected thereby.

The electric motor is a very simple machine containing the minimum number of parts and but two lubricated bearings. The gas engine, on the contrary, is a rather intricate machine, containing a large number of parts which must work in perfect co-ordination with each other in order to produce the desired results.

The motor moves with a smooth, easy motion derived from the continuously and steadily maintained magnetic pull. The gas engine receives its power from intermittent and violent explosions, the energy from which must be received, equalized and delivered through the intermediary of a large fly-wheel in order to produce even and approximately constant speed. The merest tyro knows that it must cause the expenditure of a really sensible amount of energy to keep this large fly-wheel in rotation, and energy costs money.

The racking nature of these explosions makes for a short life in the engine, whereas the steadily applied magnetic pull in the motor makes for extended life. An electric motor properly designed and reasonably well used may easily be operated for from fifteen to twenty years, whereas an explosive engine will usually fail long before the termination of such a period—or, at best, repairs required during the time may be sufficiently heavy to more than double the cost of the original investment.

The electric motor is practically reliable under all conditions as a prime

mover. The gas engine is, to a great extent, unreliable. It is a rare thing that an electric motor is out of commission one-half dozen hours a year, and, taking all gas engines together, it would probably be rare to find machines of this nature which have not been out of commission for from three days to a week in a year. The wasted time and diminution of product on one such occasion may often involve financial losses greater than the difference in cost of power between the motor and engine for a whole year.

General statements made by engine salesmen relative to the number of cubic feet of gas consumed per horse-power hour are often very misleading. The actual work which may be obtained from a cubic foot of gas depends almost wholly upon its thermal value. As an illustration of the wide variation in composition of various gases, we find that natural gas may contain from 800 to 1000 heat units per foot; illuminating gas from 600 to 700; producer gas from 300 to 400. As a matter of fact, there are probably few engines of medium and small size which do not require in excess of 16 to 18 cubic feet of first-class illuminating gas, containing from 650 to 700 British thermal units per foot per horse-power per hour.

This is especially true after the engines have been in use for some time and if they are not thoroughly overhauled, cleaned and adjusted at frequent intervals.

When we investigate the very large power plants using gas engines supplied with producer gas, we find that they furnish motive power at less cost than can ordinarily be met by any central station. Where blast furnace gas or producer gas from wood or very cheap coal can be produced in large quantities, the cost of operation may be, and undoubtedly has been, brought below 1 cent per brake horse-power per hour. These exceptional figures are attained, however, only under conditions which central electric stations would be rarely called upon to meet.

A very usual guarantee for gasoline engines is 1 cent per horse-power hour. This, however, assumes a high quality of gasoline, rich in heat units and purchasable for about 10 cents per gallon, which is far below the present price. Investigation of customers' bills will usually develop the fact that such estimates as the above are very largely exceeded in actual practice.

Not only is it found difficult at times to obtain gasoline of 74 degrees to 76 degrees, but more frequently consumers have no means of testing its quality. Again, if gasoline be not very carefully stored, it not only wastes, but it is said to materially deteriorate in its thermic value.

It is fair to suppose that makers of gas or gasoline engines rate them on the basis of using as high a quality of gas or gasoline as is readily attainable. If the purchaser of such engines does not thereafter succeed in obtaining similar fuel, he has no redress from the engine builder.

Although so many strong arguments may be adduced in favor of the motor, per se, yet they are not always sufficiently convincing to persuade the prospective customer to adopt the motor-drive. Many users of power dislike to be dependent on any outside source for their service. They feel uneasy in relying on service which they do not personally control. Broadly considered, it would be just as sensible for them to insist on owning a mine from which to obtain their own metal, or a forest from which to obtain their own lumber, as to refrain from purchasing power from an electric light station because they cannot absolutely control it. This argument must often be met, nevertheless, in attempting the sale of motors.

In approaching a prospective power customer, some of the arguments which should be availed of and fully elaborated are, low cost of initial installation and cheapness of maintenance, certainty of adequate power supply for all demands, ability to locate the motor without encroaching on valuable floor space, freedom from fire risks, simplicity of construction, ability to start and stop quickly and without adjustment or manipulation of valves or levers, extreme steadiness of speed, thereby leading to increased production of more perfect goods, freedom from danger to employees, ability to adopt group or individual drive, as circumstances warrant, with consequent saving of losses in distributing shafts, ease of changing to larger units if required, and, finally, reliability of service under practically all conditions.

In approaching such a customer, who already has a gas engine which it is desired to replace by a motor, the most opportune time is obviously when some trouble has developed. When a gas engine breaks down the circumstances are usually such that the owner is thoroughly disgusted with it for the time being. Then is the propitious opportunity for offering temporary electric service, and when once installed enlarging on the advantages which will accrue to him if he will adopt it permanently.

Although the natural gas supply, which, in certain sections of the country, has heretofore enabled gas engines to be operated at very low cost, now seems to be on the wane, the use of fuel gas is increasing and the apparatus for preparing it is being continually simplified and cheapened. I am of the opinion that the tendency towards the use of explosive engines is increasing and can only be met by the managers of stations interesting themselves in making a very aggressive campaign for motor business through experienced solicitors, offering attractive power rates and taking a lesson from the methods which the gas fraternity have adopted in enlarging their sales of gas stoves.

In closing this paper, I desire to quote from an article read by John Langton, Esq., of New York City, before the American Institute of Mining Engineers, in October, 1903, which paper as a whole evidently so far met the approval of one of the largest manufactures of gas producers and engines in this country that it was reprinted and has been extensively circulated by the manufacturer. The paper deals with the installation of gas engines at the plant of the Moctezuma Copper Company at Nacozari, Sonora, Mex., and describes a station in which gas engines are used for driving large generators, the power from which is distributed over the works by motors. I quote only a few excerpts from the section entitled, "Remarks on the Use of Gas Engines," in the closing pages of the paper:—

"The sustained capacity and satisfactory working of a gas engine depend on its being kept in thoroughly good condition. The principal meaning of 'good condition' is that the valves should seat freely, and be tight when seated; and that the inside of the cylinder should not be foul with carbonized oil. Leaky or sticky valves and dirty cylinders are the cause of nine-tenths of the ills peculiar to gas engines. A gas-valve sticking open may cause the engine to run away; but, with this one exception, every other trouble manifests itself by reducing the capacity of the engine, or by bringing it to an actual stop. Hence, good condition is essential to satisfactory operation. It is easily maintained by periodical attention—cleaning the cylinders, slightly regrinding the valves to their seats, and a care of the igniters, which differs according to the type of igniter used.

"This general examination should be made methodically and at regular periods, after the engine has been running a certain number of hours, as determined by experience in each plant. It cannot be deferred indefinitely to suit occasional shut-downs, without danger of the engine giving trouble; and it necessitates shutting down from one to three hours. Where

reliable or continuous service is necessary, the required opportunity and leisure for periodical inspection can be obtained only by having a spare unit in each group of gas engines. It is hardly too much to say that this is one essential feature in planning a gas engine plant, which constitutes the difference between a plant which will be thoroughly satisfactory in operation and one which will be eminently unsatisfactory.

"The rated capacity of a steam engine being approximately at that point of cut-off where it uses steam most economically, there is always available considerable reserve capacity at the expense of economy, by admitting steam for nearly full stroke. The most economical capacity of a gas engine is its absolute maximum capacity when at every admission it takes the maximum quantity of mixture in the best proportions of air and gas and ignites it at exactly the right point. The adjustments necessary to obtain all these conditions with certainty at every stroke are too fine for any but test conditions.

"To allow for variations, which are inevitable, even under the best conditions in commercial working, the maximum capacity should be discounted about 15 per cent. to get at a figure which may be called 'maximum commercial capacity'; and nothing more than this latter figure should be counted upon for those short periods which occur, even with the most uniform load, when the load rises to a maximum greater than the average. In other words, this commercial maximum capacity should equal the peak of the load curve. With a very variable load, therefore, an engine capacity is required greatly in excess of the average power demand; and any method of averaging the power variations of individual loads by driving several such loads from one group of engines will reduce the total engine capacity to be installed.

"When the original load on a gas engine, which is belted directly to the shafting, outgrows the capacity of the engine, it is generally difficult to devise satisfactory means of supplementing the engine power. There is a fixed charge of cost and trouble attaching to each engine, irrespective of its size, which makes it undesirable to use engines much smaller than the average size. This is frequently a hampering condition. Gas engines are not self-starting, and cannot be started with the load on. Tight and loose pulleys will answer for small engines, but those of more than moderate power need clutch pulleys on the shafting. They need good foundations, and they occupy a floor space large in comparison with their power. Additions generally require floor or shafting space which is not conveniently available. And, furthermore, when several engines are driving directly on the same shaft, it is difficult to be certain that the proportion of gas to air, and other adjustments are so regulated that each cylinder is doing its full share of the work. In fact, it may be taken as certain that the combined capacity obtained from such a group of engines will not be equal to the sum of their individual capacities. In their adaptability to meet changing power demands, gas engines are much less flexible than are steam engines.

"At points of power consumption, the mechanical character of electric motors are in striking contrast to those of scattered gas engines. Motors of any size may be used appropriate to the work to be done. They are compact, and need no other foundation than a stiff floor. The motor does its work without attendance, and is easily stopped and started by any workman. It is probably the most robust of all forms of driving machines, and will stand an ordinary amount of abuse and neglect without serious damage, and with nearly unimpaired efficiency. It has a large temporary reserve capacity in excess of its rating, and varies little in efficiency from light load to overloads. And if a local increase of power is needed, generally two or three hours' work is all that is required to supplement a motor with a smaller one or replace it by one of greater capacity."

The Value of Water Power

By ALTON D. ADAMS

ELECTRICAL transmission and distribution have given increased value to thousands of water powers throughout the country. By means of electrical transmission it is possible to deliver great powers at distant points, from water falls that cannot become centers of industry. Transmissions from the wilds of Wisconsin to St. Paul, and from the mountains of California to Los Angeles and San Francisco are examples of this sort.

Even where population and industries naturally gather about a water power, its value is much increased by electrical distribution, because of the much wider area over which it is practicable to locate the industrial plants. No better example of this fact need be cited than the great growth of manufactures at Niagara Falls since electric power began to be distributed there in large units.

In spite of facts like these the valuation of water power for use in electrical supply is an intricate problem, and not every fall can be developed at a profit. Factors that enter into the value of a water power for electrical purposes are always numerous and varied in character and often uncertain.

One of the first facts to be determined in a given case is the amount of power available. On this point the man with a water privilege to sell frequently has exaggerated ideas. Of course the power depends on the quantity of water passing a cross-section of the stream per second, and on the height of the fall. The latter is generally easy to determine, but the former for a given stream is often subject to very wide fluctuations. At Oxford, N. H., for example, the mean discharge of the Connecticut River during March, 1902, was 16,314 cubic feet per second, and in September of the same year the like mean was only 3,453 feet per second. Even when the mean monthly discharge of a river is well known, the vendor of a water right may expect to be paid on the basis of the maximum power, even though the electric system can use little more than the minimum flow.

With wide variations in the water available for different months in the year, the problem is not only to provide for fixed charges on hydro-electric plant that must lie idle a large part of the time, but also to find customers that are willing to purchase intermittent power. On most streams the storage of surplus water from month to month would require an investment on which an electric system could not hope to earn a fair return.

Another factor affecting the power available from a stream is the daily fluctuation of discharge. This, in a stream of steep descent and rocky bed, may be very large. An example may be taken from the Androscoggin River at Rumford Falls, Me., where the maximum discharge was 18,486 cubic feet, and the minimum 3165 feet, in March, 1902. It is usually possible to provide storage for at least a part of the daily fluctuations in the volume of a stream, but even this amount of storage adds largely to the cost of water-power development.

Having determined approximately

the amount of power that can be obtained from a stream in the different months of the year, another step in the valuation is to learn what market can be found for the energy developed.

The power of the stream will have a relatively small value if its hourly rate of discharge during the months of low water can be utilized only in the short daily period of maximum lighting load, for this period is not longer than two or three hours.

If the surplus flow of the river in the dry months can be stored during those hours of each day when it is not wanted for electric lighting, and all of this surplus can be used to carry the maximum lighting load, the value of the water power will be materially increased. A similar addition to the value of the power development can be made if a load of electric motors, electrolytic plants or electric heaters can be got to utilize the daily surplus of water above that required by the lighting load during those months when the flow of the stream is near its minimum. The load of motors may be of the stationary type, in factories, or may operate electric cars, but better prices will usually be got for the power in the former case.

Unless the water power is very large in comparison with the population and the manufacturing industry in the territory that it is to serve, the several classes of load just named will usually absorb its entire amount during those months when the discharge of the stream is near the minimum. But if a large part of the volume of the river must go idly over a dam during the period of relatively high water which lasts for more than six months of each year, the value of the power development will be much below the otherwise possible figure.

As a rule, it is much easier to find customers for power that can be supplied during the entire year than for power that can be had only during certain months. This fact often leads those who operate hydro-electric plants to install steam power equipments so that a load approximately equal to the maximum water power may be carried continuously. If by this means all of the energy of a water power can be sold, the value of the power is, of course, included; but against this increase must be set the cost of the steam plant and any loss in its operation.

In an increasing number of cases, however, where power is sold in very large units, contracts are made on the basis of an intermittent supply either between different hours of the day or different months of the year. These contracts are intended to prevent an overload on the electric water-power system, either at some times of day when the demands upon it reach a maximum, or in some months of each year when the rate of discharge of the stream is low.

In Montreal, Canada, where the electrical supply system distributes transmitted water power almost exclusively, and the connected load of electric motors aggregates about 20,000 H. P., intermittent power, as to either certain hours of each day or certain months of the year, is sold to a number of the largest consumers. Most of these large consumers have steam plants lying idle that can be put into service when the electric supply from water power is shut off. Energy from water power can no doubt be sold on this intermittent basis in a great number of cases if suitable concessions are made in rates, and the opportunity to make such sales increases the value of a water power.

Another important element in the value of a water power is its distance from a market, and also from a canal or railway. If the power is to have any value, either it must be transmitted to consumers or else consumers must come to it. The first requisite for the location of consumers at a water-power site is some efficient means of transportation.

Even with ample means of transportation the class of consumers that can be induced to locate near a water power for the sake of cheap electrical energy seems to be limited to exceptionally large uses of power, and in most cases to those lines of industry in which mechanical or electrical energy represents an unusually large part of the cost of operations.

This has been substantially the experience at Niagara Falls, Sault Ste. Marie, Massena and Shawinigan Falls, some of which at least lead all other hydro-electric plants on this continent in the volumes of their developed powers. Niagara Falls itself, which contains by far the greatest of the electric plants that are operated by water power, is a notable example of the failure of cheap power to attract a large body of small manufacturing industries.

The fact seems to be that the cost of power is only one of the many elements influencing the success of relatively small manufacturing plants. Unless a water power is very large, it seems idle to expect it to attract enough industries from the centers of population to give its electrical development a high value.

But if loads will not come to the water power, then the power must go to the loads, and so electrical transmission is the practical solution of the problem in most cases. The value that the possibilities of electrical transmission give to a water power depends both on the distance of markets and the prices at which power can be sold in them. To Buffalo, where run of mine coal is worth $2 per ton, electric power comes from Niagara Falls, 23 miles away, and in Montreal, where such coal sells for about $3 per ton, electrical energy from Shawinigan Falls, 83 miles distant, is largely distributed.

Fast Time in the New York Subway

THAT electricity is the proper motive power for rapid transit service was well demonstrated in a recent speed trial in the New York subway. A train of six cars, four of which were fitted with two motors each, made the run from the City Hall to Ninety-sixth street, a distance of nearly seven miles, in 10 minutes and 45 seconds.

The motors were rated to use 300 amperes at 570 volts, with an overload capacity of 500 amperes. At each end of the train was coupled a car of steel construction throughout, the interior fittings being of aluminium and fire-proof wood. The remainder of the train was made up of wooden cars, copper sheathed. These cars are later on to be superseded by the steel cars. The Westinghouse system of multiple control is employed so that all the motors may be operated from any one motor car.

The cars are well lighted with 26 incandescent lamps of 10 candle-power and have a seating capacity of 52 with standing room of about the same capacity. The seats are arranged in the manner common to the elevated railway cars, seats for 16 passengers facing front and rear, and the remainder extending along the sides of the car.

The "Rio de Janeiro Light & Power Company," which will commence operations at an early date, was recently organized under the laws of the State of New Jersey. It proposes the reorganization of the gas company and the consolidation and improvement of the various street car companies of Rio de Janeiro. An American electrical engineer, located in Sao Paulo, Brazil, Mr. James Mitchell, is at the head of the company.

Of the six largest copper mines in the world, four are in the United States, the Anaconda mine of Butte, Montana, furnishing one-seventh of the entire world's supply of copper, and the Calumet and Hecla mine in Michigan nearly one-eighth.

Some Tests of Electric Motors and Other Figures

By ARTHUR WILLIAMS

From a Paper Read at the Recent Newcastle (N. H.) Meeting of the Association of Edison Illuminating Companies

EXACT figures upon the average use of various types of lighting and power installations, offer an element of information of the greatest value in the sale of electric current.

Yet, curiously, the subject is one upon which very little information in published form exists, and that which we have is largely a matter of guess rather than of exact statement.

Average use, even within common class lines, differs widely. Knowing these differences, approximately at least, accurate estimates upon the service required for a given purpose may be readily obtained, and they give a kind of information which, checking incorrect statements, enables one to successfully meet competition. Overestimate, even to a slight extent, seemingly fair and probable, will often deprive the central station of a service to which it is entitled. And, reversely, divided into the real or assumed costs of private plant operation, this error reduces the kilowatt hour to a value entirely fictitious and misleading, possibly causing misunderstanding in many directions.

It is not suggested that, even within given class lines, a common figure upon average use can be found, but rather that the average and the conditions which cause variation being known, fairly exact estimates for a stated purpose can be made, and that this can be done with at least the accuracy which prevails in steam engineering, in estimating upon the heating requirements of a building long before it is beyond the paper stage.

AVERAGE USE OF TWENTY-FIVE LARGE BUILDINGS

Of twelve large buildings in New York City (Manhattan), the average daily use of each installed lamp in a recent year was 3.22 hours. The range was from 2.75 hours, 14 per cent. below the average, to 5.11 hours, 58.7 per cent. above; in one instance the average was 6.5 hours, practically 100 per cent. above the general average.

Thirteen office buildings, forming another group, had a daily lamp average use of 3.2 hours.

AVERAGE USE OF FIVE CLUBS

Of five large New York clubs the annual use of each lamp averaged 4.75 hours. The range was from 3.7 hours, 22 per cent. below, to 5.5 hours, 16 per cent. above the general average of daily use. It is to be expected, I think, that the conditions controlling club lighting would be less subject to changes of an extreme nature than those controlling an office or other mercantile building.

Those familiar with the buildings may quickly find an explanation for these differences; the use to which they are devoted; their height and depth; the width of the street and the height of neighboring buildings; the wall and ceiling finish and furniture of the offices (more often a factor than is usually supposed); free or metered service to tenants; not infrequently the employees' attitude toward the supplying company—all are factors of variation in one way or another.

Average use in classes ought to be as well known as are the rates of the company. The price at which current is sold is only one factor in the cost, and often it ought to have a second place. Price in combination with use represents cost and as a basis of consideration one is as valuable as the other. In contracting it is often wise to disregard the kilowatt-hour rate and deal only with final costs. The value of the kilowatt-hour is seldom understood and its use frequently leads to erroneous conclusions. A given rate, by itself, may seem high, and yet, taken in relation to the purpose in view, may be exceedingly low, as the electric elevator with its low use factor; and a rate which seems low may be high, as sometimes in refrigeration where the average use is continuously at a maximum.

Absurd and elementary as it may seem, agents and not a few engineers, well informed on other subjects, frequently estimate the average use as high as all the hours of daylight, or darkness, and unless checked, they seldom fail to place the operation of motors at nearly 100 per cent. of their capacity every working hour of the year. This is so often enough to be carefully guarded against where the company is opposed by competing service. The most serious competition is that of the private plant in which there is the greatest chance for mistaken estimates. It has the further advantage that to many its operation is an interesting field of experiment and study, and its advantages, so called, in one form or another, are advocated by many eminent engineers.

AVERAGE USE OF FIFTY INDUSTRIAL MOTORS

As in lighting, so in power—investigation shows that average use is much lower than would be expected. The following figures, based upon a test of fifty motors, bear out this view. The result was reached by watt meter readings; the rating is the manufacturer's. Smelting works, average use daily, 0.48 hours for each horse-power of the rated capacity; instrument makers, 3 hours; machine shops, 2.1 hours; general machinery, 4.56 hours; hat manufacturing, 1.48 hours; waist makers, 3.77 hours; skirt makers, 7.14 hours (showing the heavier machinery required for this branch of tailoring); jewelry factory, 2.93 hours; woodworking machinery, 0.36 hours; printing presses, 2.48 hours; ice cream freezers, meat chopping machinery, etc., 9.9 hours; marble works, 1.63 hours. The average of all was 2.26 hours—daily use, let me repeat, of each rated horse-power.

ESCALATORS

The escalator, or moving stairway, is a recent application of the electric motor. The 9-H. P. motor driving the escalator at the Fifty-ninth Street station of the Third Avenue elevated railroad of New York averaged 3.1 hours of daily use and the 30-H. P. escalator at Twenty-third Street and Sixth Avenue, 3.12 hours. The mean of these figures will probably represent a fair average for this kind of work.

In passing it might be noted that in these tests but a few instances have been found where the power consumed in productive work has not been surprisingly small, and perhaps still fewer where belting and shafting transmission do not consume an amount sur-

prisingly large. Upon installation there is also a tendency to overestimate the capacity of motors needed —less frequently a virtue than is supposed. A 20-H. P. motor will be installed where the average load does not exceed ten and the maximum twelve or fifteen horse-power; yet in goes the larger size, operating nine-tenths of the time at poor economy.

Another instance of wasteful use of current, high operating costs and consequent dissatisfaction with the service, is found in the method of gearing. The motor will be connected through a fixed set of gears for its maximum rather than average speed, with the result that for a large part of the time the motor runs on the starting box. This is a real, not a fancied practice, and one usually prolific of bill troubles. Where complaint is made of motor service, the controlling rheostat should receive a large share of the preliminary attention.

In the following tests, data will be found upon several types of motor service, other than elevators, which are treated in another paper. In each instance the kilowatt-hours are given, and the cost of corresponding service, anywhere, at the local rates, may readily be determined.

LINOTYPE MACHINES

This installation consisted of fifteen Mergenthaler machines, operated through belts and counter shafting by a 5-H. P. motor. The test was made under normal conditions, prevailing from day to day:—

Number of machines	15
Average number in operation during test	11
Duration of test, hours	8
Kilowatt hours consumed during test	17.4
Average hourly consumption, kilowatt hours.	2.07
Average hourly consumption, each machine, watt hours	188
Hourly cost of each machine at 10 cents a kilowatt hour	$.0188

The kilowatt cost taken is perhaps higher than would be the charge of any of the large companies for like supply—it is assumed simply for the purpose of showing the cheapness of this service.

CEILING FANS

Some uncertainty exists as to the cost of ventilating fans and the following test may be of interest, though it is not offered as one of great importance. The test lasted one day and the fans were the individual ceiling type with blades 30 inches in length:—

	Hours
Duration of test	24
Number of fans in use during test	21
Number of fan hours	157
Number of kilowatt hours consumed	24.9
Number of kilowatt hours consumed per fan hour	.158
Cost of service per fan hour, at 10 cents a kilowatt hour	$.0158

This test confirms the accuracy of the general statement that the cost of operating these fans is between one and two cents an hour. Ten cents is about the average price at which this kind of service is given, and as the blades are capable of adjustment to different angles there is probably sufficient variation between the large number tested to have met a common average of position and consequently a common average of current consumption.

SEWING MACHINES

Very rapid strides have been made in the application of electric power to sewing machines. Originally the practice was to install a single motor and transmit the power by shafting and belting. The wastefulness of this method has led to a small sewing machine motor fastened to the stand, operated by the treadle and subject to the same case of control as if it were foot driven. Two tests were obtained, one having belt-driven, the other, direct-connected machines.

Sewing Machines, Belt Driven

	Hours
Duration of test	9
Number of machines on countershaft	60
Average number in operation	42
Number of machine hours	378
Kilowatt-hours consumed during test	13.5
Kilowatt hours consumed hourly	1.5
Kilowatt hours consumed per machine hour.	.0357
Cost per machine hour at 10 cents a kilowatt hour	$.0035

Sewing Machines, Direct-Connected Motors

	Hours
Duration of test	9.5
Number of machines installed	112
Average number in operation	63
Number of machine hours	598.5
Kilowatt hours consumed during test	11.9
Kilowatt hours consumed hourly	1.25
Kilowatt hours consumed per machine hour.	.0199
Cost per machine hour, at 10 cents a kilowatt hour	$.00199

The machines in the first test were engaged in manufacturing lace materials, in the second, hats, of a heavier nature, and any manufacturing advantages are with the first test. Therefore the more significant is the fact that, operated by belting and shafting, a machine hour requires .0357 kilowatt hour—35.7 watts—while operated by a motor, directly connected, the consumption is reduced to .0199 kilowatt hour—19.9 watts. In other words, the plant operated by belting and shafting consumes 75 per cent. more power doing the same work. The insignificance of the cost, under either test, should also be noted; at the highest it is only two-thirds of an incandescent lamp hour, at the lowest, one-third. The advantages of direct-connected operation are greater than these figures show, for to this method should be added the absence of much of the noise and vibration occasioned by shafting, of belt care and of oil dropping bearings, incidental to a long line of shafting. On the other hand, the direct-connected motors require more attention than a single motor, but adding the cleaning and oiling of the shafting and the attention required by the pulleys and belts, the resultant difference after all may not be great.

MACHINE SHOPS

Tests of this nature are usually meaningless, for the reason that the consumption of current depends largely upon the character of the work, which will vary from day to day. However, in this instance, the range of machinery is wide and special effort was made to insure that during the test the conditions were as nearly average as it was possible to have them. The equipment consisted of:—

1—8-inch screw lathe.
1—Small milling machine.
4—Drill presses—medium, 12-inch. 16-inch, 22-inch swing.
4—Lathes, 10-inch, 11-inch, 12-inch and 14-inch.
1—Grinder.
1—Shaper, 12-inch stroke.
1—Emery wheel.
1—Metal band saw.
1—Hack saw.
1—Gas forge.
1—Buffing wheel.
1—Bumping machine.
1—Large milling machine.
1—Screw machine.

There are 92 feet of shafting in the shop and the motor is five horse-power.

Running light the motor consumed	0.672 kilowatts
Motor and shafting together consumed,	2.112 kilowatts
Average hourly consumption, shop in normal operation	3.6 kilowatts
Average percentage of power consumed doing useful work	41 per cent.

The example of a small machine shop of this character was taken purposely; usually less question concerning electric power exists in the larger establishments where the engineering talent is of a high order. Even where the installation of machinery reaches a large aggregate, it is usually so divided into groups that these figures are not without some element of application.

EXHAUST FANS

Two tests of this type of apparatus were made—one fan being 9 and the other 6 feet in diameter. The first is said to be the largest in New York. It is directly connected to a 20-H. P. motor and runs at a speed of 150 revolutions a minute. At this speed noise and vibration are largely eliminated, but the ineconomy of the method is obvious.

Fan 9 Feet in Diameter

Diameter	9 feet
Speed	150 r. p. m.
Capacity (150 r. p. m.) per minute	46 500 cubic feet
Average load on motor	12.33 kilowatts
Kilowatt hours consumed per 1,000,000 cubic feet of air exhausted	4.42

Fan 6 Feet in Diameter

Diameter	6 feet
Speed	325 r. p. m.
Capacity (325 r. p. m.) per minute	35,000 cubic feet
Average load on motor	3.6 kilowatts
Kilowatt hours consumed per 1,000,000 cubic feet of air exhausted	1.72

Estimating current at 10 cents a kilowatt-hour, the cost of exhausting 1,000,000 cubic feet of air by the slow-speed blower is 44.2 cents; by the high-speed, 17.2 cents—about 39 per cent of the cost of the former.

HIGH-SPEED EXHAUST FAN

The test of this blower, at this increase in speed, was made for the purpose of extending the range of this data. It exhausts the air of a stereotyping room, heavily laden with smoke and stifling odors.

Diameter	30 inches
Size of motor	2 horse-power
Speed of motor	650 r. p. m.
Capacity (650 r. p. m.)	4,500 cubic feet
Kilowatt hours consumed per 1,000,000 cubic feet of air exhausted	5.61

VACUUM CLEANING

This is something new in the application of electric power and is one of the most modern additions to the equipment of a building. The outfit consists of a vacuum pump, electrically driven, attached through a system of fixed piping to a flexible suction hose, by which all dust and dirt are taken up without disturbing or contaminating the air of the room. The apparatus ought to have a wide and desirable application.

Size of motor	10 horse-power
Speed of motor	835 r. p. m.
Method of connection	Noiseless chain
Size of vacuum pump	14 x 8 inches
Vacuum maintained—minimum 10 inches, average 19 inches, maximum 25 inches	
Vacuum maintained during test	19 inches
Average load on motor	7.9 kilowatts
Kilowatt hours consumed to draw 1,000 cubic feet of air (at 19 inches vacuum, 9.25 lbs. per square inch) through the pump	.501

It is claimed that a building of the average size, containing, say, 500,000 cubic feet of air, can be cleaned thoroughly in three hours. For this approximately 29,000 cubic feet of air ought to be drawn through the vacuum pump, requiring, according to the foregoing test, slightly less than 14.4 kilowatt-hours of energy.

PRINTING PRESSES

There has been no greater opportunity for the electric motor than that which has been offered in the printing industry. The load factor is low and the advantages, such as instantaneous readiness and control, and relative cheapness in cost of operation, compared with other methods were early recognized. The larger newspaper establishments are either using or considering the use of electric motors attached directly or by belt or chain drive. It has been recently stated that one of the largest printing press makers in the country no longer sells his best product without a direct-attached electric motor. A great deal of attention has been directed to the attachment of motors, and many methods have been patented for their economical and satisfactory control. Some of these systems possess much merit, and one has reached a point where a simple movement of a lever starts or stops the press without shock or jar, the speed at any point being practically proportional to the movement of the lever. In all of the following figures, regulation wastes, such as they are, have been taken into consideration, and the results given represent the net costs of production from the meter to the printed sheet.

Huber Flat Perfecting Press—Reciprocating Motion

Size of motor	5 horse-power
Hourly capacity of press	1,000 impressions
Number of pages to each impression	8
Size of page	8 inches x 11½ inches
Current consumed per impression	2.87 watts
Current consumed per 1000 printed pages	.360 watts
Cost per 1000 pages at 10 cents a kilowatt hour	3.6 cents

Hoe Webb Book Press—Rotary Motion

Size of motor	10 horse-power
Hourly capacity of press	3,500 impressions
Number of pages to each impression	144
Size of page	4½ x 8 inches
Current consumed per impression	5.1 watts
Current consumed per 1000 pages printed	.35 watts
Cost per 1000 pages at 10 cents a kilowatt hour	0.35 cents

Large Webb Octuple Press.—This is said to be the largest newspaper press operating in New York City, there being one still larger, but not yet in full operation. Power is supplied by two 37½-H. P. motors, one at each end of the press. Thus, half the press can be disconnected when the full capacity is not required, but the motors are started by the same controlling switch and are regulated by the same rheostat.

The series-parallel method of control, which includes two windings to each armature, each winding having its own commutator, is used. When starting, the first point on the controlling switch, through a resistance, throws the two windings in series; as the switch moves forward, the resistance is gradually cut out and the two windings are thrown in parallel again through the resistance, which again is gradually cut out as the press is brought to full speed. The movement of the press is gradual and steady, starting and running to full speed and stopping again, without jar or other disturbance.

The speed at which a press of this kind can run, amongst other things, depends upon the quality of paper used. Poor quality under strain will break frequently and cause loss of time in making repairs and again starting the press. Better quality naturally stands a higher strain and can be run through the press at a higher speed without breaking. The slow speeds are maintained with the rheostat, which introduces a large element of waste. Two tests have been made, therefore, one with poor paper, running on the fourth or fifth of the ten notches of the controlling rheostat, the other with better paper and the press operating at full speed.

Starting, the inrush current on each motor is between 85 and 90 amperes, at 240 volts. During the first test at slow speed 35,940 twelve-page papers were printed with an expenditure of 40 kilowatt-hours of energy, an average of 1.112 kilowatt-hours for each thousand complete papers. Under the second test made at the full speed, 11,400 twelve-page papers were printed, consuming an average of 920 watt-hours for each thousand complete papers. The increase in the use of electric energy, printing the poorer paper at the slower speed, exceeded 20 per cent.

Four Sextuple Webb Presses.—This group of presses is operated by a 250-H. P. motor with belt and counter-shafting transmission. Each press has an hourly capacity of 41,000 copies of a complete eight-page newspaper. The starting conditions for these presses were as follows:—

Steps on Rheostat	Amperes	Volts at Brushes
1	420	20
2	350	80
3	200	180
4	150	200
5	80	210
6	55	215
7	50	220
8	50	228
9	45	236
10	45	238

Only three of the four presses were running during the test, the fourth being under repair; but as more than three presses are seldom used, the conditions in this respect were fairly average. The further details of this test follow:—

Motor running light	11.52 kilowatts
Motor and shafting	21.6 kilowatts
Motor and average load	57.1 kilowatts
Proportion of average consumption of current required to operate motor and shafting	37.6 per cent.
Proportion which average horse-power bears to the capacity of the motor	30.6 per cent.
Eight-page papers printed during test	88,900
Kilowatt hours consumed during test	77
Watt hours consumed per 1000 complete papers	867

One Sextuple Webb Press.—This press is operated by a 65-H. P. motor, directly attached. As it is of the same design and capacity of the presses referred to in the preceding test, a fairly close basis of comparison between belt transmission and direct connection is offered. On starting, the current was as follows:—

Steps on Rheostat	Amperes
1	15
2	25
3	70
4	130
5	150

The time taken to reach full speed was fifty seconds; the average pressure during the test was 240 volts; the average current was 60 amperes.

Eight-page papers printed during test	28,000
Kilowatt hours consumed during test	15.4
Watt hours consumed per 1000 complete papers	550

From the foregoing it will be noticed that the grouping of the presses and their operation by a single motor, thus incurring transmission losses incidental to belting and shafting, causes an increase in the electric energy consumed of nearly 60 per cent.

Multi-Color Press.—This is said to be the largest press ever constructed for color printing. It is driven by an

80-H. P. motor, and has a capacity of 20,000 eight-page papers hourly.

Eight-page papers printed during test	28,980
Kilowatt hours consumed	18
Watt hours consumed per 1000 eight-page papers	620

These results give further evidence of the efficiency of the direct-connected motor. The grouped Webb presses, where the power was transmitted by belts, consumed 867 watts in printing 1000 eight-page papers, the single press of the same size directly attached to the driving motor consumed 550 watts, and here, in the heavier color work, 620 watts were required.

ELECTRIC REFRIGERATION

This subject is receiving a great deal of attention on the part of central station men. It is probable that there will be a large development in artificial ice making and cooling in the near future, as machines are perfected and the public appreciates their many advantages. Refrigeration has the advantage that it is almost entirely a summer load; like a battery, it can also be eliminated from the peak load, summer or winter.

First Test.—The first test was of a 5-ton refrigerating machine used for cooling the drinking water of a large manufacturing establishment. The refrigerating coils are in an immense tank surrounded by filtered water maintained at a temperature of 40 degrees Fahrenheit. An electric pump causes this water to circulate through the building, in the entire course of which it loses but one degree of temperature, Fahrenheit. The result of the test was as follows:—

Capacity of machine	5 tons
Size of motor	12 H. P.
Method of connection	noiseless chain
Speed of motor, r. p. m.	600
Kilowatt hours required hourly to maintain a ton of ice effect, excluding rheostat losses.	1.11

The capacity of the machine is largely in excess of the requirements of the building, consequently the motor runs at reduced speed. During the test the starting box was in series, in which there was a loss of 34.2 per cent. of the energy consumed. It is, therefore, probable that with the motor more closely rated, the plant would operate with materially increased economy.

Second Test.—A second refrigerating plant having a capacity of ten tons was tested for the purposes of this report. The machine cools the cold storage rooms of a large restaurant and hotel where wines, provisions, etc. are kept, and produces 1200 pounds of ice daily. The following are the details of the test:—

	Kilowatts
Average power consumed driving compressor	15.3
Average power consumed driving brine pump	.94
Total	16.24
Kilowatt hours required hourly to maintain a ton of ice effect	1.63

It is evident that there is no reason why electric refrigeration ought not to become universal.

ELECTRIC ROCK DRILLS

The electric rock drill, replacing steam and compressed air, popular in the West, is a new device which as yet has not made much headway in the East. Under test, one of these drills gave the following results:—

Depth of hole bored	7 feet 2 inches
Average diameter of hole	2 inches
Drilling time	19.08 minutes
Power required to operate drill	3.95 horse-power
Total consumption of current	940 watt hours
Consumption of current per foot of drill,	131 watt hours

A foot of rock was drilled with an expenditure of 131 watts, which at a cost of current as high as 10 cents a kilowatt-hour would amount to only 1.31 cents a running foot. It has been reported that the minimum cost of steam or pneumatic service is about 10 cents a running foot.

ELECTRIC PUMPING

The electric pump is entering upon a period of prosperity. Its manifold advantages have become so apparent that the Board of Aldermen of New York City recently so amended the building code that it now holds equal place with steam pumps. The object of the following test is to ascertain the cost of pumping water by electric power, the motors being attached directly to the pumps they operate.

Small House Pump.—This is a 5 x 8-inch triplex pump, operated by a $7\frac{1}{2}$-H. P. motor, directly attached:—

Dimensions of pump	5 x 8 inches
Strokes per minute	120
Speed of motor	1090 r. p. m.
Pressure pumped against	92 lbs. per sq. in.
Water lifted	213 feet
Gallons of water pumped during test	1,615
Pounds of water pumped during test	13,450
Efficiency of motor and pump	45.1 per cent.
Average horse-power during test	7.16
Kilowatt hours consumed per million foot gals.,	6.98
Kilowatt hours required to pump 1000 gallons against an average pressure of 100 pounds per square inch	1.61

Large Fire Pump.—This is an 8 x 10-inch triplex pump, operated by a 50-H. P. motor, directly attached:—

Dimensions	8 x 10 inches
Strokes per minute	120
Speed of motor	620 r. p. m.
Pressure pumped against	91 lbs. per sq. inch
Water lifted	210 feet
Gallons of water pumped during test	7,590
Pounds of water pumped during test	63,300
Efficiency of motor and pump	58.2 per cent.
Average horse-power consumed during test	58
Kilowatt hours consumed per million gals.	5.41
Kilowatt hours required to pump 1000 gallons against an average pressure of 100 pounds per square inch	1.25

The large pump consumed 29 per cent. less current than the small one.

Portable Wireless Telegraph Apparatus for War Service

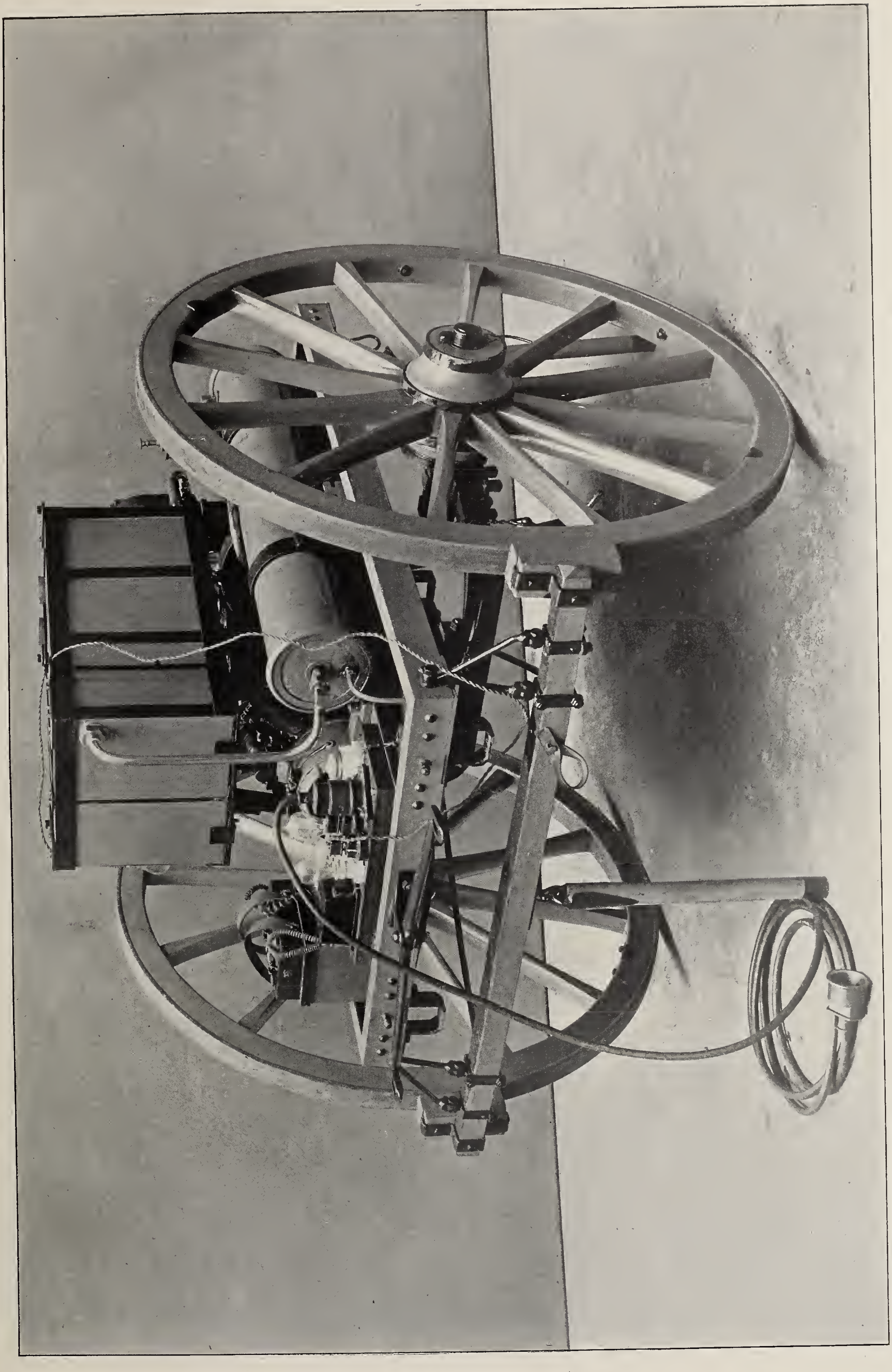
By DR. ALFRED GRADENWITZ

THE important role of wireless telegraphy in warfare is being evidenced by the war at present between Russia and Japan. The interest this means of intercommunication receives in military circles is quite universal, as wireless telegraphy seems to be destined to remedy a number of drawbacks inherent in ordinary telegraphy and telephony. In fact, any defect occurring in the telegraph wires will entail a temporary disablement of the line in question, and the locating of the defect will oftentimes require more time than the laying out of a new line. These difficulties, it is true, are partly eliminated by using induction currents and receiving the signals with telephone, but the absence of any written signals constitutes another serious disadvantage. Moreover, in case of a station being taken down the time will mostly be wanting for taking off the wire, and the amount of wire necessary will require a rather bulky train..

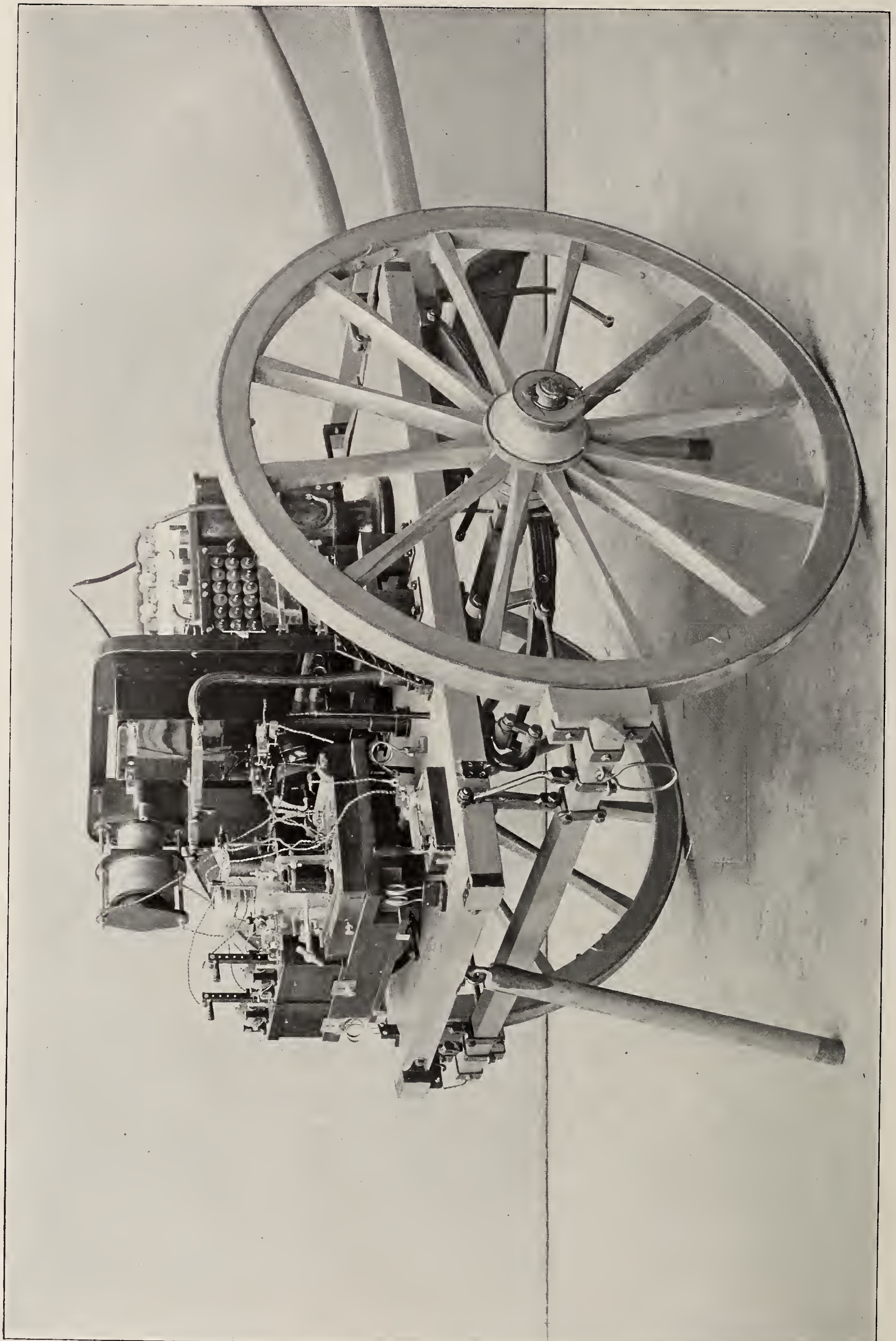
The "Gesellschaft für Drahtlose Telegraphie," of Berlin, which operates the "Telefunken" system (being a combination of the Braun-Siemens & Slaby-Arco systems) has paid special attention to the use of wireless telegraphy both for naval and military purposes. On one hand communication between land and ships and from ship to ship, has been effected by the company with perfect success through distances as high as several hundred miles. On the other hand, about forty portable stations have been supplied to the military departments of several countries. The system has been adopted by the German, Austrian and Russian armies, and it is probable that Sweden and Spain will likewise soon decide in its favor.

According to the results so far obtained, successful communication up to more than four days' marching is possible when working with the Morse recording apparatus, while in the case of sound recording of the signals, the distance may even be double the above.

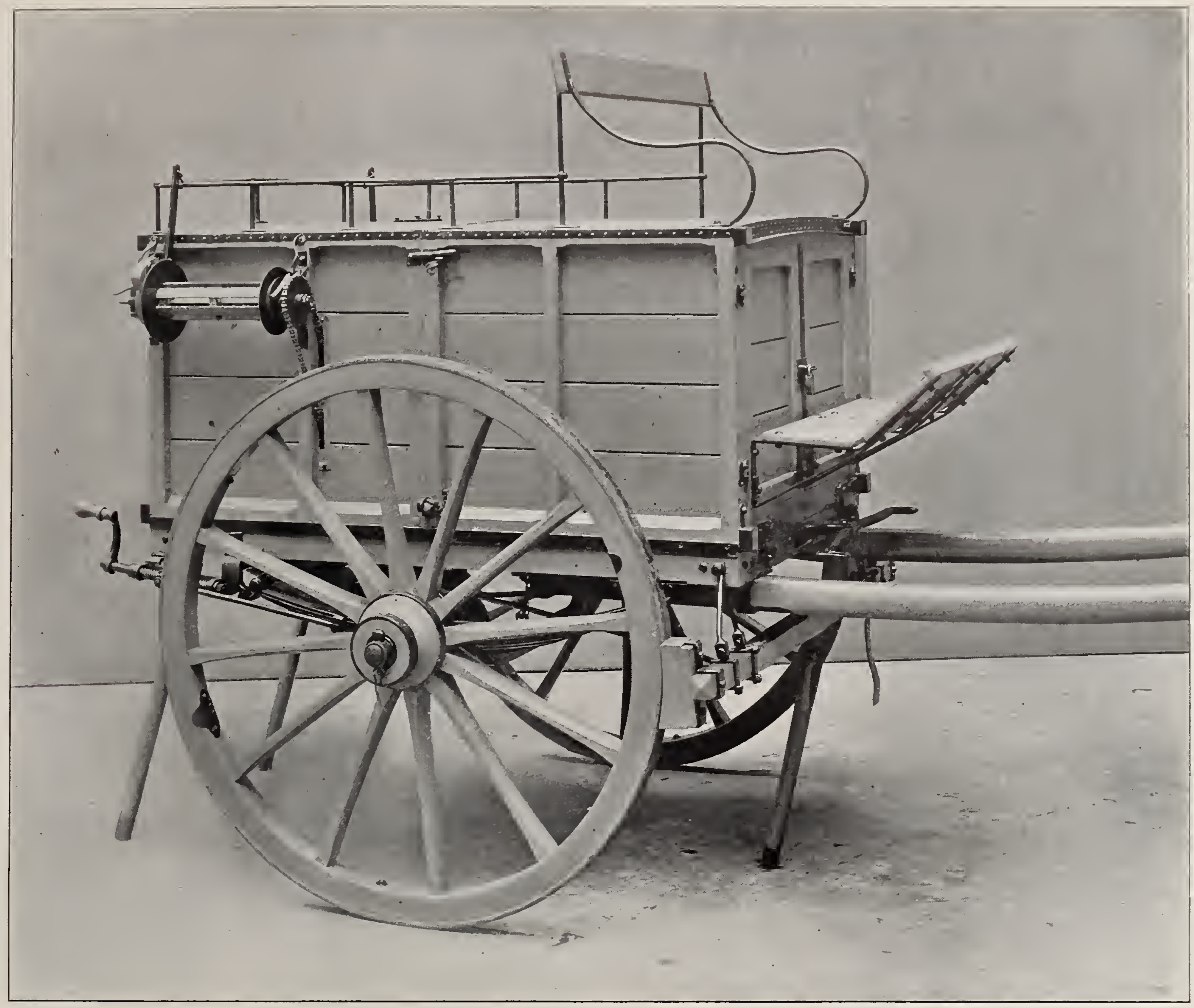
In the latest form of portable station for war purposes built by the above company, provision is made for two wave lengths, namely, for a short wave of 350 m. and a long wave of 1050 m., the antenna remaining the same for both. In the case of the short wave the antenna will oscillate in



A GERMAN PORTABLE WIRELESS TELEGRAPH OUTFIT FOR WAR SERVICE. THE POWER CART WITH CASING REMOVED



MILITARY WIRELESS TELEGRAPH APPARATUS CART WITH ENCLOSING CASE REMOVED



THE POWER CART CLOSED IN, READY FOR TRANSPORT

three-quarters, and with the long wave in one-quarter of a wave. The antenna is supported either by kite balloons or by linen kites.

Each station comprises three two-wheel carts, a power cart, an apparatus cart and a utensile cart. The power cart contains the current source, consisting of a benzine motor of about 4 H. P., direct coupled to an alternating-current generator of about 1 K. W. capacity, and the exciting machine.

The cooling of the motor is effected by water, carried along in a reservoir located above the engine. The circulation of the water is effected automatically by means of a small cog wheel pump, the water being cooled by a tube system and by a ventilator. Benzine is carried in a reservoir of about 30 liters in capacity, located beside the water tank, this capacity being sufficient for a continuous telegraphic service of about thirty hours.

The balloon is pulled in by means of a cable drum controlled by a friction coupling. A full supply of accessories and reserve parts is provided in the tool box fixed outside of the cart.

The apparatus cart, separated into two compartments by a frame, contains both the sending and receiving apparatus. In the front part are located the high-tension instruments, comprising the induction coil, a battery of Leyden jars, with adjustable spark gaps and the high-tension transformer.

In the back part are arranged the Morse key, and on a board placed on good springs, two receiving apparatus and a Morse recorder, while on the board of the latter the smaller receiving transformer is located. On the frame separating the car has been arranged the large receiving transformer, the receiving plug as well as other auxiliary apparatus. On one of the side walls there is the former, the receiving plug as well as a sounding apparatus, comprising an electrolytic detector and a telephone, while on the door an easily removable alarm bell has been placed. These instruments have been so installed as to allow of the upper part being removed without breaking any connection.

The accumulator necessary for lighting purposes is placed in a box at the left-hand outer side.

The utensile car contains the gas reservoir and the necessary intrenching tools as well as the balloon and a reserve benzine reservoir. The gas reservoirs are built direct into the car and have each a capacity of about 35 cubic feet, at a pressure of 120 atmospheres, two reservoirs being sufficient for filling the balloon with the aid of a filling hose.

The New Australian Patent Law

By JAMES HAMILTON, M. E., LL. B.

LEFT to what is practically self-government on their island continent, our Australian cousins have solved problems in a way which has elicited approval from the foremost nations—approval which has in many cases found expression in adoption. The Australian law governing the election of public officers has proved a model after which have been fashioned the election laws of nearly all countries, and advocates of the Australian method of settling labor disputes are to be found among the foremost thinkers in the industrial world. A new Australian law on a subject of such widespread industrial interest as that of patents for inventions naturally engages the attention, and in what follows a comparison of the provisions of this new law with those of the patent laws of this and other leading commercial nations will be made.

Comity between nations has found expression in the provision that "any person, whether as a British subject or not, may make an application for a patent." In this lack of distinction between subject and alien, Australia has followed the laws of all the principal patent-granting countries. It is to be noted, however, that not until the statute of March 3, 1903, amending our law regarding the filing of caveats, did an alien have in this country all the rights of a citizen, although since 1836 an alien has had equal right with a citizen to file an application for and obtain a mechanical patent.

The right to make application for an Australian patent must be obtained from the actual inventor in those cases in which he himself is not the applicant. Here is a departure from the British law which has been criticised unfavorably for its permitting the grant of a valid patent to a thief who has stolen the invention from a foreign country. During the revival of learning following the Dark Ages, England was far behind the leading Continental countries, because of her insular position; and in order to promote knowledge and progress of the useful arts, the Saxon kings rewarded those who made the then perilous journey to the Continent and brought back to the realm knowledge of some new and useful manner of manufacture. The usual form of this reward was that of a patent giving the recipient the exclusive right for a period of years to produce the invention or carry on the method of manufacture thus imported. Though the reason for the rule has disappeared with the advent of the arts of printing and telegraphy and the facilities for travel, patents granted the communicatee of one not the actual inventor are sustained, even though the communicator may have stolen the invention.

A much more rigid rule is established in this country, where the applicant must not only be the actual inventor, but must also establish a "prima facie" right to the grant by making an affidavit in prescribed form. He only it is who may sign the papers, while in Australia anyone claiming under him may sign them. In nearly all the important countries of Continental Europe, anyone claiming under the actual inventor may make application in his own name, and in most cases without giving any proof of his right. Like our own law, the Australian law is careful to protect the rights of representatives of deceased inventors and of those who through insanity or other disability are unable to make required declarations.

As to what may be the subject matter of letters patent, the new Commonwealth's law servilely follows the British law, saying that "invention means any manner of new manufacture, the subject of letters patent and grant of privilege within section 6 of the Statute of Monopolies" (21 James I., c. 3). It may be that through judicial interpretation the term "manner of new manufacture" has come to have a definite meaning; but one cannot help entertaining a feeling of uncertainty about a term under which patent rights were for nearly two centuries denied to processes, until Chief Justice Eyre, in passing upon Watt's invention, embodied in the steam engine, stretched by what may be called judicial statesmanship the meaning of the term to include the method of doing a thing, a mode of treatment, a process.

Under the comprehensive enumeration in our statute, "art, machine, manufacture or composition of matter" (copied in the Canadian law), little question has arisen or can arise as to what is of a patentable nature. However, disregarding exceptions expressly made, as military inventions in Russia, medicines in nearly all the countries of Continental Europe (although several grant patents for processes of manufacturing medicines), foods and chemical products in several European countries, the subject matter of patents does not differ greatly under the laws of the several countries; it must be new, useful, involving the exercise of ingenuity in its production and susceptible of being exploited industrially.

The degree of ingenuity required to be shown varies much, however, in the practical administration of the law. Thus, our Patent Office is more liberal than the German Patent Office in attributing invention to a given change. So, also, novelty is determined by rules somewhat artificial. Thus, under the Australian law, proof that the invention was known over fifty years ago, but not used in Australia within that period, will not destroy the quality of novelty under the new law; in Hungary the period is one hundred years, while in this country no time is prescribed. The granting of a patent in any country destroys the quality of novelty in Austria; a year from the issue of the patent is allowed in Canada; the grant of a foreign patent for the same invention has no effect in this country, provided the United States application is lodged here within one year from the date of filing the first application; while Australia follows the British law and requires a sufficient description of the invention to be published in Australia, as a printed copy of the specification and drawings, or, in some cases, a copy of our "Patent Office Gazette."

The new Australian law requires an examination to be made into the novelty of the alleged invention before the grant of a patent. The scope of the search will be a matter of administration of the Patent Office, for the statute itself is far from clear upon this point. Among other things, the examiner is required to ascertain and report as to whether the invention for which a patent is asked is already patented in the Commonwealth or in any

of its component States, or described in any prior application filed therein, and to "report as to whether, to the best of his knowledge, the invention is or is not novel." It would seem from this that something more is required than a search limited to Australian patents and applications, unless, indeed, the examiner is to depend upon his individual knowledge of the art.

But since the grant of the patent may be opposed by any person on the ground "that the invention has been described in a book or other printed publication published in the Commonwealth before the date of the application, or is otherwise in the possession of the public," the examiner's search may, perhaps, include printed copies of patents, publications of foreign Patent Offices and the literature of the art. In any case the requirement that a search be made is a departure from the practice under the laws of the several Australian States, which were satisfied by an examination touching matters of form—that is, as to whether the title had been stated, the invention described and the application and specification drawn as prescribed—without going into the merits, and passing upon the patentable novelty of the invention.

In this country a rigid search is made by the examiner, the scope of which includes all patents, domestic and foreign, books, periodicals, trade journals and the like, irrespective of the language. Moreover, the examiner passes upon the question of invention and of utility, and may reject because, within his knowledge, the invention is in public use. Searches of a scope equal to that required by our practice are made in Germany, Austria, Denmark and a few other countries. Great Britain recently passed a law providing for the examination, as to novelty of applications, breaking away from the old system which required no more rigid examination than was required by the practice in the several Australian States, and which, therefore, left it to the courts to pass upon the question, when controverted, as to whether the invention was patentable. This is the policy adopted under the recent change in the French law. In Belgium, Spain and Italy not even this examination into matters of form is made, the system pursued in these countries being analogous to our registration of title deeds and the like.

As a patent under any system—such as registration, examination as to form only, or examination as to both form and merits, entailing a search—is only a right to sue, it has been contended that a patent should be granted in every case, leaving to the determination of the suit the right to the patent; and that to force the applicant to overcome the objections raised by the Patent Office authorities before he can obtain his patent, and again to establish his case before the courts, is to require that he go over the same ground twice. It is pointed out also that in this country under the search system, the courts, while holding that proof of the grant makes a "prima facie" case as to validity, refuse to grant a preliminary injunction in a suit for infringement upon bare proof of title and infringement, and require, therefore, higher degree of proof as to validity than that coming from the grant.

The requirement as to search in the new Commonwealth's law is undoubtedly a step in the right direction, and is in keeping with the change in the law of the mother country and with the practice in the leading industrial countries. Patents granted under the search system are entitled to respect; they are issued only after a careful inquiry into the state of the art by an expert in that art; and the public is reasonably sure that an article properly marked "Patented," embodies an invention entitled to the protection of the courts. The patentee, on his side, is made aware of prior work in the same field of invention and of the limitations imposed upon his claims thereby, and so is not deceived into the assertion and attempted maintenance of rights to which he has no title.

While our courts require for a preliminary injunction that the patentee prove acquiesence by the public in the validity of his patent, a decision sustaining it upon final hearing in a "bona fide" suit, or some equally strong proof of its validity, although a careful search was made before its grant, yet it must be borne in mind that the requirement of such a search, the existence of facilities for making it and for confirming its results tend to the desired acquiescence and to a favorable decision in a suit properly instituted. In short, a search inspires confidence in the public that it is not being robbed of its rights, and that the patentee is entitled to his reward, confidence in the patentee that he and those claiming under him may invest time, money and effort in bringing the invention to public notice without fear of successful imitation after its establishment in public favor, and confidence in the courts that some substantial addition to the world's knowledge must have been made before the strong arm of the law can be invoked in the protection of patent rights.

It has been urged against the search system that it is responsible for the suppression of many meritorious inventions to which illiberal examiners have denied patent protection, whereby the progress of science and the useful arts have been impeded. How slight is the basis for such a contention can be perceived when one remembers that in case of rejection by the primary examiner, the applicant has a remedy by appeal. In Australia, an appeal is made to the law officer on questions of form, and to the High Court or Supreme Court on questions relating to merits. In this country an appeal is made on questions relating to merits first, to a board composed of three examiners-in-chief; second, to the Commissioner in person; and third, to the Court of Appeals of the District of Columbia. It follows that small, if any, chance exists for the refusal of a patent upon anything which displays a spark of ingenuity. To safeguard still further the rights of an applicant, the Australian law provides that the Commissioner may, if he believes good ground exists for refusing to accept a specification without condition, accept it on condition that a reference to such prior specification as he thinks fit be made thereon by way of notice to the public.

This idea is not new with the Australian Legislators, for it was advocated by Llewellyn Deane, Esq., of Washington, over thirty years ago; yet it is the first time such a provision has been embodied in law. After the grant of a United States patent, all papers filed by the applicant during the progress of his application, and all Patent Office letters and actions are open to public inspection, so that information may be readily obtained at small cost as to what references were cited by the Patent Office. To amendments made by the applicant in response to objections from the examiner in relation to matter of substance, the courts in this country have wisely attached great importance in determining the scope of the claims, and have uniformly held that where an applicant has by amendment narrowed his claim in order to procure his patent, he is restricted to the claim as allowed and estopped from asking an interpretation thereof so broad as to exclude the limitation imposed by amendment.

It would aid greatly in the interpretation of claims if our Patent Office would print at the end of every specification a list of the references cited and the claims canceled or modified in view thereof. It seems a step back-

ward to provide, as is done in section 51, of the Australian law, that reports of examiners shall not be published (except, of course, to the applicant) or be open to public inspection, or be liable to be inspected or produced in any legal proceeding unless the court or person having power to order inspection or production certifies that such inspection or production is desirable in the interests of justice and ought to be allowed. No good reason appears why the public ought not to be given every facility in determining what has been withdrawn by the patent from unrestricted public use.

After the acceptance of the complete specification in Australia, the application and its accompanying specification is laid open for public inspection for three months, within which period any person may oppose the grant upon any of several enumerated grounds, among which are: that the invention is old in that it has already been patented in the Commonwealth, or one of its States, or described in a printed publication or is otherwise in the possession of the public before the date of application; that the opponent has filed, prior to its disclosure by the applicant in the complete specification, an application for the invention, not disclosed in the provisional specification; that the applicant has no legal right to apply, and so on. The parties are heard by the Commissioner, with appeal to the courts from his decision.

This procedure is unknown to our laws or those of Canada, but has long been in vogue in Great Britain, Germany, Austria, Denmark and the several States of the Australian Commonwealth. In this country we depend upon the oath of the applicant to establish his status as the true inventor, and upon the search of the examiner to ascertain the state of the art. The United States examiner takes cognizance of interfering applications and institutes interference proceedings to determine priority of invention between the interferants. If a careful search be made by the examiner, little is left to be developed by an opposition, except the matter of a prior public user. Evidence offered to support such user has always been scrutinized carefully by the courts here, and proof beyond a reasonable doubt of such user has been always required.

The facts regarding the user rest in "the slippery memory of man"; honest men may be easily mistaken as to what they saw years before, and interested parties are not lacking in the art of persuading witnesses at such times. It is easy to foresee the abuse to which such opposition would be put in this country by large corporations if it were permitted. Skillful counsel and plenty of money for litigation would enable them to harass an applicant until they could buy in the invention at their own figure. The interest of the public and of inventors is served far better by keeping the application secret and "ex parte" until it matures into a patent, and relying upon our examining corps of scientific experts to guard the public interests.

In this country there is no limit upon the time during which an inventor may publicly experiment with his invention before he applies for a patent, provided he is diligent and the use is not made with a view of deriving profit, but merely with a view of perfecting the invention—a "bona fide" experimental use. In Australia, however, the applicant is limited to one year prior to the lodging of his application. In this country an inventor may have his invention in public use or on sale or described in a printed publication for a period not exceeding two years without forfeiting his right to a patent therefor; but the Australians have adhered to the illiberal British rule and denied the inventor the right of making public his invention (except by way of test or exhibition, public or private) before filing his application.

After the grant of the patent, the Australian law requires the patentee to work his patent—commercially exploit his invention—within two years to such an extent as to satisfy the reasonable requirements of the public, or to grant licenses on reasonable terms to others, under penalty of revocation of the patent. In this policy Australia follows the mother country, and the requirements seem to be as light as possible while making any provision whatever as to working. All the European countries make some requirement as to working a patent granted by them; but whenever a change is made in the law upon this subject it is generally to make the requirement less burdensome by the extension of time, acceptance of good reasons for default, or granting compulsory licenses.

Even Canada has recently admitted certain classes of inventions to compulsory license privileges. In this country no working is required, and the patentee's self-interest is relied upon to make him put his invention into public use. This seems to work well, and our industries certainly thrive without any legal compulsion as to working patents. But it would be better if every court adopted the doctrine laid down by some of our courts to the effect that patents not put into early and continued use, but which have lain dormant for years—mere paper patents, as they have been called—shall not to entitled to a construction not contemplated on their face, but shall be limited to what is shown.

In this country an inventor desiring to obtain official record of his disclosure of an invention not yet in perfected form, may file a "caveat," which entitles him to be notified of any application filed within one year thereafter and claiming substantially his invention. Because the law allows him two years within which to put his invention in public use or on sale, few caveats are filed. Australia follows the law in force in her several States and in the mother country, and allows the inventor to file a provisional application, which must be followed by a complete specification within nine months, which may be extended to ten months. A provisional specification need only "fairly" describe the nature of the invention; but a "complete specification must fully describe and ascertain the invention, and the manner in which it is to be performed, and must end with a distinct statement of the invention claimed."

In short, the complete specification corresponds to the specification which is required with our application for a patent, while the disclosure made in the provisional specification resembles that made in our caveats, and is more general. But the filing of a provisional specification is the beginning of an application for a patent, while the filing of a caveat here has no such effect. The number of claims permissible in an Australian complete specification is not limited, and the invalidity of one or more claims does not affect the validity of the remaining claims. In this the Australians have shown their sense in thus breaking away from the British rule of to-day, by which the invalidity of one claim invalidates the whole patent—a rule established by the early English judges at a time when monopolies of any kind were "odious."

The term for which an Australian patent is granted is, like that of a British patent, fourteen years. Most of the European countries grant their patents for fifteen years, and require the payment of a yearly tax to keep it in force. In this country the term is seventeen years without the payment of any tax. Australia seems to have "straddled" the tax question, and requires the payment of a renewal fee of five pounds sterling ($25) at the middle of the term, closely following Canada, who divides her term of eighteen years into three equal periods, with a fee of $20 at the beginning of each period. Some reason might be found for the requirement of a renewal fee in Australia, if the first fee

were small; but it costs $40 in government fees alone in Australia for seven years' patent protection, as against $35 for seventeen years' protection in this country.

Under the new law, Australia grants additional patents to patentees for improvements upon the invention set out in the original or parent patent. These additional patents are granted upon the payment of one-half of the fees prescribed for the parent patent and expire therewith. This is an innovation as regards Australia, but additional patents have long been granted by most of the countries of Continental Europe. They are, however, unknown to the laws of this country, Great Britain and Canada.

The new Australian law is unquestionably an improvement upon the British law on the same subject, but departs not widely from the latter. A careful study of the new law fails to show that we have anything to learn in patent legislation from our Australian cousins. The citizens of the United States live under the most liberal and wisest of existing patent laws, the wisdom of which finds ample confirmation in our progress in science and the useful arts, our leading position in the industrial world and the millions of capital to-day invested in vast industries founded upon patent rights. The one regrettable feature is the parsimonious manner in which this more than self-supporting bureau is treated by Congress, the unjustifiable illiberality of whose appropriations prevents the full accomplishment of the purpose of the laws—the reward of the original and first inventor.

Recent Electrical Mining Developments in California

ONE feature of recent mining development in California, according to C. G. Yale in "The Engineering and Mining Journal," is found in the electric plants and transmission lines which furnish power to the leading mining districts. Among such enterprises now projected is that at Junction City, a small place a few miles from the town of Weaverville, in California. Here the North Mountain Power Company has purchased the water rights of the old Compagnie Francaise, which formerly operated hydraulic mines, and will use the water to generate power. The mines are nearly worked out, and the old company has no further use for its ditches and water supply. The plant is to be installed on the barren bedrock at the old McGillivray claim, where the ditch runs along the mountain side 600 feet above the point chosen for the power house. Electricity from this plant will be transmitted as far as Eureka in Humboldt County, and power will be supplied to purchasers all along the Trinity River from Junction City to Eureka, for use in mines, dredges and the like. There is much virgin dredging ground in this region.

At Etna, in Siskiyou County, the center of a flourishing mining region, the Siskiyou Electric Power Company is putting a new power house. This company recently brought out the Etna Development Company, and will use the Fall Creek power house built by that company, in addition to the new plant which it is building. Transmission lines will supply many mines with power. In Shasta County two new companies are preparing to use the waters of Hat Creek by diverting it in flumes to the power plant which they are about to build. In Plumas and Sierra Counties also several companies are arranging to build dams and establish power plants to supply the mining districts.

These instances are given as examples to show the extensive work which is now being done to utilize the power of the mountain streams within the mining region. There is, of course, in California an especial inducement for such work by reason of the high price of fuel, which is an important factor in the cost of mining and milling in the State.

Electrical Enterprise in the Philippines

THE Manila Electric Railway and Light Company, which is hastening to completion with American material an extensive system of electric traction in Manila, P. I., has just acquired the interest of La Electricita Compania Anomima, which Spanish capitalized concern operates the only lighting system in Manila. The franchise acquired is good until 1917, after which time it will be extended for a period of ten years if the bid is the lowest. The Manila Electric Railway and Light Company is controlled by American capital; James F. Swift, of Detroit, Mich., is president of the company. The street railway system is being built by J. G. White & Company, New York. It is understood to have not yet been decided whether the existing plant will be used or power will be derived from the central station now under construction by the new interests.

The Camden & Trenton Electric Railroad, of New Jersey, is planning to install a block system on its line.

The Production of Glower Earths in the United States

THE production for 1903 of monazite and zircon, containing rare earth oxides used in the manufacture of glowers for electric lamps, is given in the forthcoming volume "Mineral Resources of the United States," issued by the United States Geological Survey.

North and South Carolina are the only States that furnish these minerals in commercial quantities. The total production of monazite in 1903 was 862,000 pounds, valued at $64,630, which is an increase of 60,000 pounds in quantity and of $470 in value over the production of 802,000 pounds, valued at $64,160, in 1902. This quantity represents the purified sand which contains from 85 to 99 per cent. monazite.

The quantity of zircon obtained in 1903 was 3,000 pounds, valued at $570. The total product of these minerals mined for use in the manufacture of various lamps therefore amounts to 865,000 pounds, valued at $65,200.

The Largest Station for Wireless Telegraphy

ACCORDING to a recent consular report, the largest station for wireless telegraphy yet erected will soon be completed at Pisa, Italy. The buildings will be entirely of stone. As it will take some time to put the apparatus in place, the station will probably not be ready for transmitting and receiving messages before the beginning of next year.

The station will be called Coltano. It is designed to establish wireless telegraphic communication from there with Great Britain, Holland, the United States and Canada, and also with vessels in the Mediterranean, the Baltic Sea, the Red Sea, and the Atlantic and Indian oceans. Lately two Marconi stations have also been completed on the coast of Montenegro, and are now in working order.

The Sociedad Tranvias de Saragossa, Spain, has requested the City Council to grant it a concession to make several extensions of its present system of tracks. Rumor has it that the concessions will be granted, in which case the street railway company will have to make purchases of steel rails and additional rolling stock.

The electric light and power plant, of Christiania, Norway, is to be enlarged, and the management, therefore, are expected soon to be in the market for electric machinery and supplies.

THE ELECTRICAL AGE

Volume XXXIII Number 4
$2.50 a year; 25 cents a copy

New York, October, 1904

Entered at the P. O. as 2d-class matter.

ESTABLISHED 1883

Published monthly at 3, 5 and 7 W. 29th Street, New York City.

Telephone No. 1617 and 1618 Madison Square. Private branch exchange connecting all departments. Cable Address—Cassier, New York.

SUBSCRIPTION RATES

The Electrical Age will be sent post free anywhere in the United States and its possessions, Canada and Mexico for $2.50 per year, single copies 25 cents. To Great Britain and all countries embraced in the postal union, $3.75, 15 shillings, 19 francs, 15 marks, or 10 rupees. Send subscriptions to our nearest branch office or agency.

NOTICE TO ADVERTISERS

Insertion of new advertisements or changes of copy cannot be guaranteed for the following issue if received later than the 15th of each month.

LONDON OFFICES

Business Department, 33, Bedford Street. Editorial Department, 22, Henrietta Street. Covent Garden, Strand, W. C.

London Telephone, Post Office, 3807 Central. Private branch exchange. London Cable Address—Revolvable, London.

All remittances to London Office should be crossed London and County Banking Company.

BRANCH OFFICES AND AGENCIES

Subscriptions may be sent to the following branch office or agencies, where they will receive the same careful attention as at the home office in New York:

124, Queen St., Melbourne
359, George St., Sydney
61, Main St., Yokohoma
23, Esplanade Rd., Bombay
33, Loop St., Cape Town
Unter den Linden, 5, Berlin
Nevsky Prospect, St. Petersburg
31, bis rue de Fauburg Montmartre, Paris

General Agents for United States and Canada: The American News Company

Leading Articles

Electric Power Transmission on the Pacific Coast. By L. M. Hancock.... 241
Windmill Electric Plants. By H. C. Judson.. 257
Single-Phase Electric Railroads. By W. A. Blanck.... 262
Fuel Economy in Electric Station Power Plants. By John B. C. Kershaw.... 269
Gas Engines versus Electric Motors. By Fred. M. Kimball.... 274
The Value of Water Power. By Alton D. Adams.... 277
Some Tests of Electric Motors and Other Figures. By Arthur Williams.... 279
Portable Wireless Telegraph Apparatus for War Service. By Dr. Alfred Gradenwitz.. 282
The New Australian Patent Law. By James Hamilton.... 286
Wireless Telegraph Prospects.... 290
Power Station Piping.... 291
The Widening Use of the Electric Pump.... 292
Telegraphy and Telephony in Japan. By Saitoro Oi.... 293
Notes from the Tour of the Visiting Foreign Electrical Engineers. By Wm. Maver.... 299
Mathematics in Engineering. By Thorburn Reid.... 302
Depreciation on Electric Railways. By W. E. Harrington.... 318

Wireless Telegraph Prospects

WITHIN the past month the record distance for overland wireless telegraph signalling in this country has been increased from 107 to 300 miles, the successful operators having transmitted signals from St. Louis to Chicago by the De Forest wireless system. The country between Chicago and St. Louis is practically level, and therefore is better suited, theoretically, to wireless transmission than a mountainous country would be. The results of these experiments were attested by Professor W. E. Goldsborough and a jury appointed by the Exposition authorities. A notable feature of the tests was that the cities of Chicago and St. Louis intervened between the two transmitting stations, the results of previous experiments having indicated that the intervention of cities would prove to be a serious obstacle to the transmission of wireless signals.

Wireless signaling overland is, of course, not altogether a novelty. It is, for instance, well known that Fessenden has had in experimental operation a circuit between Jersey City and Philadelphia, a distance of about 100 miles for more than a year. In the experiments also that Marconi carried on between the Mediterranean and Poldhu, England, in 1902, it may be remembered that signals were reported to have been received from Gibraltar, and beyond—a distance of 750 miles, several hundred miles of which were over land. These last mentioned signals were, however, sent in one direction only, namely, from Poldhu to the Italian cruiser, Carlo Alberto, the transmitting apparatus at Poldhu being very powerful. In the De Forest experiments between St. Louis and Chicago, the masts were 200 feet high and twenty vertical wires were employed. It is now stated that attempts will shortly be made to open up communication by wireless telegraphy to New York from St. Louis—a distance of 1200 miles.

In the event of these recent overland experiments being continued, it will be interesting to ascertain, if such a thing be feasible, whether the overland telegraph and telephone wires and the numerous railroad tracks between the various cities named, play any part in the transmission of the electric waves. It was suggested, when the trans-Atlantic experiments were made, that the Atlantic cables might have played some part in the transmission of the signals, but it was then pointed out that the high capacity of these cables precluded the transmission of rapid electric waves by their means. On the sliding wave theory of propagation of electric waves over the surface of the earth and sea, however, it is within the possibilities that the multiplicity of wires and rails may facilitate the transmissison. The necessity for the large earth plates used in the present experiments, namely, 140 square feet of copper, buried 8 feet in the ground and kept constantly damp, would tend to bear out this view. Likewise, if there be merit in the Fessenden wave chute, which consists of comparatively small metal conductors extending along the earth from the foot of the vertical wires, a distance of several hundred feet in the direction of transmission, there ought to be additional merit in the presence of railroad tracks extending practically the entire distance between the wireless stations.

While the success of any new wireless experiments will probably always be made the occasion of exuberant jubilation by the promoters of the successful system, such success, regardless of the distance covered need not occasion any surprise to the initiated, since theory indicates that with an unlimited number of wires and a sufficiently large generator for charging the wires, there is practically no limit to the distance to which signals may be transmitted. But in view of the well recognized atmospheric and other causes that conduce to irregularities in wireless transmission, the transmission of wireless signals experimentally for a few minutes at a time between any two points, whether over land or sea, cannot be taken as a measure of the amount of business that may be transmitted continuously over that circuit. At best the amount that a wireless circuit or two, in the present state of the art, will add to the existing overland wire facilities, is but a drop in a bucket, which remark is made with full knowledge of the great and recognized value of wireless telegraphy where wires are not available.

Contemporaneously with the announcement that Dr. De Forest has succeeded in sending messages by his wireless system from St. Louis to

Chicago, 300 miles, comes the prediction by the promoters of the enterprise that in the course of a few months messages will be sent direct from Seattle, in the State of Washington, to the Philippine Islands. "If this is accomplished," says the careful reporter, "the trans-Pacific cables will probably be abandoned as a means of comunication (to what other use could they be put?), and the millions of dollars invested in the cables will be a dead loss."

If the changes had not been rung ad libitum on this (to the holders of cable stock) dreary subject, when four or five years ago certain other interests were predicting the immediate opening up of trans-Atlantic wireless communications, with all sorts of dire consequences to the existing cables, which, by the way, are still doing business at the old stand, some credence might be placed in the present predictions, but with the long list of promises unfulfilled as to trans-Atlantic wireless telegraphy, they must be gullible indeed who will give patient attention to any statements relative to trans-Pacific wireless telegraphy, however specious, that fall short of actual proof of the regular commercial transmission of business.

Apropos of President Roosevelt's remark relative to carrying the big stick, it is interesting to note that the car conductors on a certain portion of the electric railway in Montreal are required to carry a stick for a very useful purpose. Where the line passes over the Lachine Canal and several parallel forebays for water power at St. Gabriel locks, the road is single track, owing to the limitations of the bridges. Because of several turns in the road there it is impossible to see from one terminal of the single track to the other. To avoid the inconvenience that would ensue from the meeting of two cars on the single track, not to mention the possibility of serious accidents, the company has provided a painted stick about 1 foot in length which is handed to the conductor about to cross the bridge, the possession of which stick entitles the conductor to the right of way. When this car reaches the other side of the bridge the conductor passes the stick to the conductor of the car there waiting to cross in the opposite direction, and the latter is now habilitated with the right of way. He, in turn, when he reaches the other end of the single track, hands the stick or baton to the conductor of the first car he meets coming in the opposite direction. It is an imperative rule of the company that no car shall start over this restricted portion of the road unless the stick is in that car, and this ensures that but one car at a time can be on the restricted portion of track. In case of a blockade at points remote from the bridge this system is, of course, at a disadvantage, but it appears to suffice for the end in view. This use of the stick, as the insignia of right of way on railroads, is, however, not altogether peculiar to the city of Montreal, inasmuch as it was in vogue years ago in a number of instances in Great Britain, and possibly other places on single-track railroads.

Power Station Piping

THE design of power stations has undergone many notable changes within the past few years. Direct-connected engines and dynamos have almost universally become standard in place of the less efficient and more troublesome belted machines of older days; concrete and steel construction has distanced the wooden architecture of ten years ago through its decreased fire risk and superior permanence; mechanical stokers and power-driven traveling cranes have come into more extended use in large plants; relay switchboards and motor-operated circuit controlling devices have been born of the difficulties of handling heavy currents and high voltages; boiler and engine rooms are better lighted and ventilated to-day than ever before, and finally, the size of generating units has increased until in some quarters the opinion is expressed that a practical limit has been reached in the concentration of power in a single machine.

But the end has not been reached yet, so far as the introduction of new apparatus and methods is concerned. The steam turbine, with its simplicity of construction and operation and its extraordinary economy of space over reciprocating engines of equal capacity, and the gas engine, with its advantages in fuel consumption per unit of output, constitute a double promise that the design of power plants shall not grow commonplace for years to come.

The piping system has felt the effect of these changes in design, and as steam pressures have mounted higher in the boiler room, the manufacturers of pipes and fittings have striven to produce equipment that would stand the strain of continuous operation at pressures up to and even above 180 pounds per square inch. That they have been successful is evidenced by the rare failures of their products.

It is not so very long ago that the steam end of the power plant was designed in a haphazard fashion in comparison with the care and thought bestowed upon the electrical portion. The boiler room was considered satisfactory if the fireman could see enough of the furnaces to shovel coal upon the grates, and questions of comfortable temperatures, adequate light, ventilation and cleanliness were thought to be of little importance. In good practice much of this indifference to the fuel side of the house has vanished to-day, but there is still room for much improvement. The piping system has often failed to receive proper attention at the hands of designers, although the manufacturers have been keenly alive to the needs of the times.

Simplicity is the rule in the best power station designs of to-day, and no piece of apparatus is justified in a plant built under modern plans unless it can be shown conclusively that its absence will cause great operating inconvenience or financial loss. There seems to be a gradual departure from the former ideas of duplication, and nowhere is this more evident than in the piping system. Instead of running double steam headers and mains from the boilers to the engines, the simpler idea of treating each generating unit with its condensing apparatus and boiler as a small individual power plant is finding favor.

Where a straight longitudinal layout of boilers and engines is possible, a single large steam header, into which all the boilers may discharge, affords the greatest flexibility if run the entire length of the boiler or engine room, provided that it is supplied with plenty of valves. If these valves are equipped with motors capable of quick action in closing and opening them at times of emergency, it is next to impossible for any very serious interruption to the service as a whole to occur. An explosion of a branch pipe or a violent leak in one section of the header will often be taken care of by isolating that section so quickly that not a single generating unit need be shut down The larger the plant, the greater is the responsibility of getting continuous service from it, and the cost of the ¼ H. P. motors necessary to do this work, with the requisite wiring, is a small percentage of the total cost of the station.

There seems to be a tendency to rely upon close inspection and first-class original construction coupled with careful maintenance, instead of the old scheme of duplicating everything from the steam drums of the boilers to the separators of the engines.

The modern power station exemplifies the old saying about the chain and the weakest link as well as anything in engineering. It is important that the piping be kept in good shape—

quite as essential as that the switchboard instruments should retain their original polish.

There is need for better work in the designing of pipe layouts and in the maintenance of installed systems, although very creditable results are being secured in the way of strength and workman-like construction. One does not need to visit many power plants to discover that leaky joints are a common disease of even some of the best installations. Every leak simply means a stream of small coins running to waste through a hole in the pocket of the operating company. Questions of compactness, support with reference to expansion, control of steam supply, simplicity of valve arrangements, depreciation and freedom from vibration are all waiting to be solved by the operating and designing engineers who become piping specialists.

The Widening Use of the Electric Pump

RECENT tests of improved types of electric pumps for use in mines and oil works and for irrigation have demonstrated in great part the superior advantages of this form over steam and compressed air systems. The durability also of electric pumps has been demonstrated, especially in South Africa, where electricity and compressed air are fighting for supremacy in the mines. In one of the shafts of the Nights Deep Mine, the electric pumps and cables abandoned there before the Boer war, were found to be in almost perfect working order after two and a half years in which the mine had been partly or wholly flooded. The motors were brought up, dried, and, after slight repairs, were put to work again.

But in lines of industry other than mining, electric pumps have also proved successful. This is notably true in Western irrigation work. In California, electrically-driven pumps are taking the place of the old-fashioned wind-mills for irrigation purposes, the latter being of value only where a very limited flow of water is required for individual use. Irrigation in California has transformed great tracts of arid land into flowering gardens and fruit orchards, the water being frequently pumped up from 50 to 1000 feet.

The dry season of the Pacific Coast is the critical one of the whole year, and unless water can be obtained in abundance when needed the loss of crops is great. The wind-mills are not to be relied upon, and steam, on the other hand is not profitable for the reason that during a large part of the year the pumps remain idle and the investment brings no return. Gasoline engines driving pumps answered the purpose to some extent for a time, but the real solution of the vexed pumping question appeared when two power companies, which had harnessed streams in the Sierra Madre Mountains for driving electric generators, offered to supply current at a low rate. At first electric pumps along the lines running from the mountains to Los Angeles, 83 miles away, were supplied with current. So successful was this enterprise that farmers at many other points along the Pacific Coast demanded electricity for driving their irrigation pumps, and, as a consequence, the whole region between the mountains and the coast is to-day dotted with electrically-driven pumping outfits. As a rule one well is driven for every 50 to 75 acres, and a small centrifugal pump, with an induction motor, completes the plant. The pumps are installed in small houses at convenient points on the farm, each station using from 30 to 75 H. P. There are two methods of connecting the motor. One is to gear it to the pump shaft, and the other to connect it by a belt. Outside of the station a step-down transformer reduces the voltage to that required by the motor.

The farmer uses the current only when water is badly wanted in the irrigation ditches. He then simply fixes his flash-board, closes an electric switch, and the pump starts up. Land that was almost valueless at first, is to-day worth from $200 to $500 per acre, and the improvement of large sections is increasing rapidly. Hundreds of fruit ranches ranging from 50 to 1000 acres have been supplied with electric pumps for cheap irrigation. The manufacture of electric oil pumps has also received considerable attention in the past year both in the United States and Europe. In the Pennsylvania and Indiana oil regions where the supply of oil must be raised from great depths, gas engines and kerosene engines have in the past been largely utilized for this purpose. The danger of fire or explosion attending the use of such engines has, however, brought about a change in pumping methods. The gas or kerosene engine is now placed at some distance from the oil well and drives an electric generator which supplies current for electrically-driven pumps. Thus the oil in one or two dozen wells may be pumped by means of the energy from one source.

In parts of Europe electric pumps for oil wells have been adopted with great success. In Roumania the system was inaugurated five or six years ago, and to-day there are nearly a hundred electric motors in use for this purpose. The operating expenses have been reduced to $40 per horsepower per year. The largest power station has a high-tension line running a distance of 20 miles through the oil region.

During the past year a number of electric oil pumps have been in operation in the Russian oil districts also. The first of these to be installed was at Balachani. Since 1901, a large electric plant has been in use by the Apcheron Company on the Caspian Sea, and others have been constructed at Bibi-Eybat and in the Baku region That at Bibi-Eybat develops 1500 H. P., and a considerable number of pumps are run by it.

Fire risks in oil-pumping regions are important items, and their entire suppression by using electricity for driving the pumps has naturally tended toward the general adoption of this system of securing the oil. Moreover. the economy obtained in other ways in the operation of the pumps is important. The wells are scattered over so wide a territory that any other power than electricity for operating them is both inconvenient and expensive. With electric wires extended to all parts of the region, both drilling and pumping are much simplified, and oil companies are therefore gradually changing their operating power from steam or oil engines to electric power, generated in some central station.

The types of pumps operated by electric power vary a great deal, according to the work required of them, and manufacturers are studying the different fields with a view to improving them so that their work may prove satisfactory beyond question. The small pumps for irrigation and for oil wells represent a line of development that insures a continuance of the new systems. The more ambitious manufacturers have steadily advanced their investigations in other lines. This is notably true where high-pressure pumps are needed for fire-fighting. Fire pumps driven by electric motors in cities are still in the early stages of development; but a number of foreign cities have adopted them in their fire departments. These pumps are lighter than the steam pumps, and are mounted on horse-drawn vehicles. Current is easily secured at the hydrants or available places near the fire alarm boxes, and the pumps can be started the instant the engine reaches the fire.

Of the eighty-seven telephone companies doing business in Pennsylvania, nine are controlled by the Bell interests; the remainder are independent companies.

Telegraphy and Telephony in Japan

By SAITARO OI

A Paper Read at the International Electrical Congress at St. Louis, September 12-17

FIG. I.—AN AUTOMATIC CALL BOX IN A STREET OF TOKYO

TELEGRAPHY was the first practical application of electricity in Japan, as it was in all other countries. It is generally believed that Commodore Perry, of the United States, when he came over to Japan in 1854, brought two sets of telegraph instruments with him and presented them to the Shogun, at that time the Lieutenant-General, or Governor-General, of the Empire.

The first telegraph line, however, was constructed between Tokyo and Yokohama in 1869, the instruments used being Bréguet's, which were employed for some time until all were superseded by Morse ink-writers. There was not very much progress until 1877, when the civil war broke out in the southern districts. This naturally necessitated an increased use of the telegraph and the lines were extended to the important places of the Empire. These thirty-six years from 1869 to 1904, have wrought a remarkable change in our social conditions in general, and in the means of communication for the public some progress has been made.

In order to show the progress made during these thirty-six years, I give the following table:—

STATISTICS OF JAPANESE TELEGRAPH AND CABLE LINES

Year	Miles of land lines	Miles of wires	Nautical miles of submarine cables	Miles of aerial cables	Number of telegraph stations	Number of telegraph instruments in use	Number of messages charged	Expenditures in yen (1 yen = 50 U. S. cents)	Receipts in yen
1869.....	20	20	......	......	2	......	....	....	....
1880.....	4,140	9,782	52	......	155	......	1,897,635	785,901	896,571
1890.....	5,890	19,800	121	......	408	734	4,039,319	1,386,381	1,256,555
1900.....	14,735	66,834	2,031	......	1,654	2,817	14,280,230	5,773,432	6,072,990
1903.....	16,600	80,213	2,178	10	2,178	4,216	16,987,760	6,234,738	6,567,487

It may be remarked here that about 3000 miles more of wires are to be added to the existing lines this year so as to meet the increase of traffic.

The foregoing table refers to those only which are used for the public traffic, except that of Formosa. There are, in addition, many private telegraph and telephone lines worked exclusively for railway and for various other industrial purposes which, according to the latest report, amount to the remarkable figures following:—

	Miles of Wire	Number of Instruments
Telegraph	10,892	1,340
Telephone	10,635	5,381

The first telegraph line in Japan was constructed by English engineers and linemen in the service of the Japanese Government. The chief engineer was E. Gilbert, who had been connected with a railway company in Scotland before he came to Japan. The methods of surveying, construction and maintenance of the land lines laid out by him were naturally after the English practice, and are continued, with more or less changes, down to the present day. The lines are built in a solid manner, so that they can withstand the attacks of storms which are almost certain once or twice in the autumn of every year.

As to the telephone lines in towns, the method of construction may be said to follow American rather than English practice, and in some places where no cables are employed, as many as 100 to 150 wires are run upon a pole planted along the side of the streets. In large towns, however, these overhead wires are generally being taken down and laid underground and, as seen from the table given later on, there are at present several miles of underground lines.

Poles are generally of cedar, which grows in abundant quantity in differ-

FIG. 2.—TYPICAL JAPANESE TELEGRAPH LINES

ent parts of the country. The number of main poles used varies, of course, with the number of wires put up and the nature of the route through which the lines pass; but in the open country there are, as a rule, from 38 to 26 per mile; and where there are too many wires for one pole to carry, trussed poles—often H poles—are employed. Ordinary main poles are 22 to 24 feet in length. Taking the average, 64 per cent. of the main poles are stayed, while 14 per cent. are strutted. Boucherizing is a common practice as a means of preservation of the poles, but lately creosoting is being tried, though on a small scale.

Boucherized poles last about 18 years on an average, whilst untreated poles begin to decay within five or six years; and owing to the fact that the price of timber, which was very cheap in the earlier days of telegraphy, has become somewhat expensive with the recent progress of engineering work in general, various compounds and methods of preserving wood have naturally had the attention of the engineers concerned. Considering, however, the different conditions of Japan, the most suitable one for telegraph and telephone purposes seems, so far, to be the boucherizing process; 46 per cent. of the poles are boucherized, the remainder being untreated.

Arms with double-cup porcelain insulators are exclusively used and are always fixed on the side of the pole facing the so-called up-station. For telegraph lines, two-wire arms of 24 inches and 34 inches are generally used, except where many wires are to be run. They are secured to the poles a foot apart, and alternately in case more than two wires have to be put up.

Telephone wires are run on 4, 6 or 8-wire arms most commonly, and long-distance lines on braced 6-wire arms. The distance between the centers of the arms is 1 foot 6 inches, the minimum distance allowed from the ground to the lowest arm being 16 feet. The span of the long-distance lines is usually 48 yards, the minimum transposition being made at every twentieth pole.

No. 8 S. W. G. iron wire is the standard for the telegraph lines, though No. 11 iron wire is sometimes used for short lines. The long circuits for fast automatic or quadruplex working are of No. 12 S. W. G. copper wire. As a rule, an earth wire is attached to each one of the poles.

For telephone lines in towns where there is not much snow No. 17 S. W. G. hard-drawn copper wire, and silicon bronze wires are used, but in the northern districts, where snowfall is abundant during the winter, No. 14 iron wire is run for subscriber's line. For the interurban telephone service three gauges of copper wires—No. 8 S. W. G., No. 12 S. W. G. and No. 14 S. W. G.—are employed.

For long spans, such as river crossings, steel is almost always used in the case of telegraph lines, and bimetallic wire for telephone circuits of long distance. There were many long spans when railways were few, but at present the telegraph lines at river crossings are attached to railway bridges, or cables are laid on the girders in a trough. The longest air span now in existence is 800 yards with steel wire. and 320 yards with bimetallic wires, each of 170 pounds per mile.

Underground construction for the telegraph lines is rather limited at present, it being confined to a part of Tokyo only; but the increase of telegraph wires from year to year, in addition to those for telephony, electric light and power, etc., shows the necessity of laying more wires under-

ground in the large towns, and it is very likely that in the course of a few years the telegraph lines in the busy part of the large towns will be put underground. The greater part of the telephone lines, however, in large cities such as Tokyo, Osaka, Kyoto and Yokohama, is already laid underground.

When the first underground construction was undertaken in Tokyo in 1896, we adopted 3-inch cast-iron pipes, and the same system was employed, to a considerable extent, in the other towns also; but my visit to the United States in 1898 gave me a favorable impression as to vitrified clay conduit, and immediately after my return home, I advised the authorities to adopt it where we have more than three ducts. Since then the single-duct vitrified-clay conduit has become the standard of underground working, as our manufacturers can make it excellently and cheaply.

Underground cable used for telegraph purposes has prepared-fibre insulation and is covered with lead pipe. The telephone cable for underground work is of the dry-core paper insulation kind, and in large towns apparatus is provided for sending dry compressed air at 3 to 4 atmospheres pressure into the cable. This proves very useful in Japan, as the cables are all imported, and if cables should get low in insulation they can be easily repaired. One-hundred-pair cable was used when the underground work was commenced, but now 200-pair cable is very common, No. 20 S. W. G. being the size of the conductors. Smaller wire cable has been suggested for some uses, but it has not yet been adopted.

Most of the lines in towns being overhead, there are naturally a great many aerial cables, both of India rubber and dry-core type, put up on poles to avoid too many telephone wires crowded together, or to cross electric light and power conductors, which are also carried along the streets like the telegraph and telephone lines.

The laying of submarine cable was considered the most difficult work, and except in a narrow strait or in a river the work was almost always executed by the Great Northern Telegraph Company's steamer. The features of the country, however, called for a number of submarine cables in various parts, and in order to establish new communications and to maintain efficient working, it became necessary to do the work with our own staff. Sometimes we equipped a steamer with rough machinery to lay a new cable or to repair a broken one, and although not without inconveniences in most cases, still we accomplished our object, and in this way our engineers and workmen have obtained some useful experience in this branch of telegraph engineering.

When Formosa was annexed to Japan in 1895, it became an urgent necessity to put the new possession in direct communication with Japan, and consequently measures were at once taken to lay cables connecting the Islands of Kiushu, Liuchu and Formosa. A cable steamer was built and fitted out at Glasgow for the purpose of laying and repairing cables and was brought out to Japan in June, 1896. The "Okinawa Maru," our cable ship, is a twin-screw steel steamer, having a double bottom. The gross tonnage

FIG. 3.—OVERHEAD TELEPHONE CIRCUITS

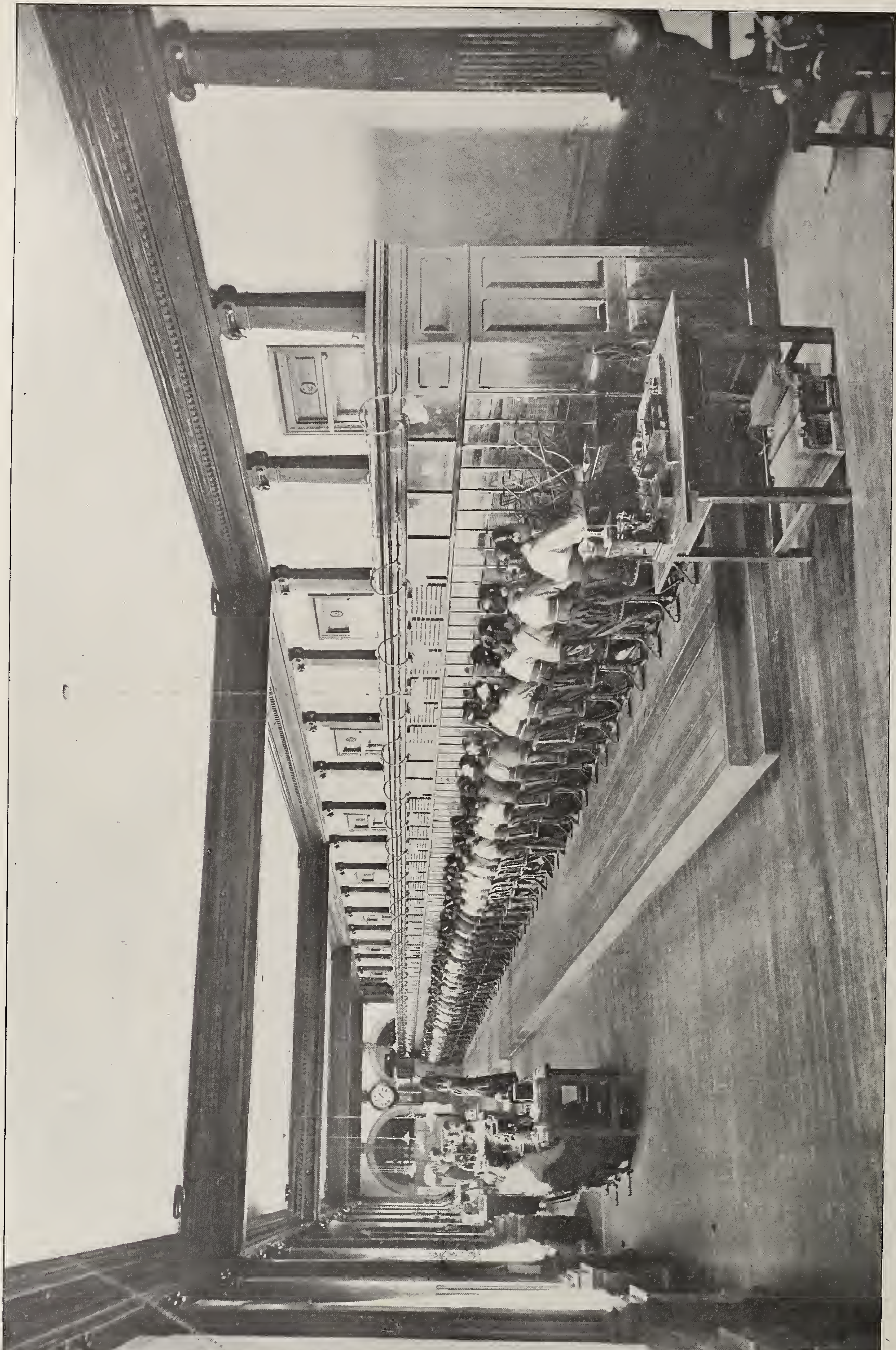


FIG. 4.—THE INTERIOR OF THE TELEPHONE EXCHANGE AT TOKYO

is 2212, the length between perpendiculars being 290 feet, the breadth extreme 40 feet, and the depth of hold 24 feet. She is equipped with triple-expansion engines, double-ended boilers, and has three cable tanks of 15,952 cubic feet, 8389 cubic feet, and 6945 cubic feet capacity, respectively.

It remained still a question with us whether our engineers could manage to lay cables in very deep waters, as our experience had been previously limited to comparatively shallow waters, and it was strongly suggested to engage some experienced foreign engineers for the work. We wanted, however, to gain all possible experience and so we took up the work ourselves. The cables were successfully laid, though not without some difficulties; they have been working well during the past eight years, being worked duplex with direct siphon recorders.

As mentioned elsewhere, Bréguet instruments were the first instruments used for the transmission of public messages, while Wheatstone needle instruments were used for the railway service. The complication of the mechanism of the former and the consequent liability to get out of order made its extensive use unsuitable, and very soon the Morse ink-writer replaced it.

Of about 1100 circuits now working, 850 are fitted up with Morse instruments and the remaining 250 circuits are fitted with telephones. Of the 850 circuits, 90 are worked duplex, 9 quadruplex, 4 automatic, and the remainder simplex. Sounders were first introduced in Japan in 1895, and have been working in comparatively large offices only. At present about 40 per cent. of the total instruments are sounders. Duplex telegraphy was tried in 1879, but its practical success dates from 1889; as to quadruplex working, it was only from 1893 that we could put it into actual use on important circuits.

The Wheatstone automatic is limited to a few circuits in ordinary circumstances; but violent storms occur among the islands, particularly in autumn, and often cause extensive breakdowns of the important lines; on such occasions the automatic working is found valuable to dispose of the accumulation of messages. Repeater boards are employed in important centers to the best advantage of working. Telegraph exchanges are confined to circuits in towns or to very short and less important lines only.

The Morse signals used in telegrams written in the Japanese characters are 50 in number, in addition to those representing figures and the signs of punctuation. These signals are partly composed of those representing the Morse alphabet, and partly of additional combinations of dots and dashes.

Telegraphically speaking, about 3.65 Japanese letters are equivalent to one word in English, which, on the average, consists of 4.67 Morse letters, and therefore one Japanese Morse signal corresponds to 1.28 international Morse signals. It may be perhaps interesting here to note how Japan is related telegraphically to foreign countries. Of the whole number of foreign messages forwarded or received, which amount to about 800,000 a year at present, about 40 per cent. are credited to Korea, 28 per cent. to China, 9 per cent. to England, 7 per cent. to the United States, 4 per cent. to India, 3 per cent. to Germany, 2 per cent. to France, 2 per cent. to Russia and 4 per cent. to all other countries combined.

FIG. 5.—THE TELEPHONE EXCHANGE AT KYOTO

Testing of lines is carried out in 24 offices located in important centers of the country. Conductivity and insulation resistances of the lines are regularly measured once a month, while the condition of the lines is ascertained every day by observing the current strength received from the distant stations.

The lines are all worked open circuit with Daniell cells, except in Tokyo and Osaka, where storage batteries have been in use since 1902. The change from primary batteries to secondary in these two large offices brought about a considerable reduction in the expense of maintaining batteries in them, and changes in the other large stations are now being planned.

The charge for inland telegrams in Japanese letters is 20 sen (1 sen = $\frac{1}{2}$ U. S. cent) per message of fifteen letters or less of text, the address of the receiver being free in this case; and for every five letters or less exceeding the first fifteen the additional charge is 5 sen. Inland messages in Roman letters are charged 25 sen per message of five words or less, the additional charge being 5 sen per word. For telegrams within the limits of a town, 10 sen per message in Japanese and 15 sen per message in Roman letters are charged; for additional letters or words exceeding the numbers allowed for one message 3 sen are charged per five letters or one word.

The telephone was first brought to Japan in 1877 by a mechanic returning home from America, and was a magneto telephone encased in a box. Soon after its introduction, the telephone was put into practical use as an auxiliary to the police service in Osaka and vicinity, a considerable length of lines being built for that purpose. Some of the circuits then constructed were more than 30 miles in length, and as many as ten such magneto instruments were connected in series on a single circuit of iron wire. As can be readily understood, conversation was no easy task, except by those who had experience in using the instrument.

After the introduction of the car-

bon microphone the application of the telephone for industrial and commercial purposes began to increase remarkably, and it was in 1883 that the idea of starting telephone exchanges first occurred to the authorities. A company was promoted for carrying on the business and a petition was forwarded to the government asking for a license to start an exchange and carry on the telephone business in Tokyo. That was in 1884. The question whether it should be carried out as a government undertaking or entrusted to a private capital remained unsettled until 1889, when it was decided, after deliberation, to undertake the work as a state monopoly.

While the matter was still in consideration by the administration, it was thought necessary that our engineers should get more detailed information for the successful working of telephone exchanges. The writer was appointed to make a tour of Europe and America to study telephone matters. My stay in Europe and America lasted a year and a half, and it was in December, 1889, that I returned home from my first trip abroad. At that time an appropriation for the telephone undertaking had already been made, and the work was to be started as soon as possible in Tokyo and Yokohama.

The executive office was opened in Tokyo, and letters and circulars were sent out to business men, to the nobility, to government officials, to manufacturers and, in fact, to any person in the city of more or less prominence. We advertised in the popular papers the opening of telephone exchanges and invited subscriptions from the general public. We did not confine ourselves to letters and circulars or to the newspapers alone, in introducing the telephone to the public, but, in addition, we put up a switchboard and telephones in the building of the Tokyo Chamber of Commerce, and in the Rice and the Stock Exchanges, and invited people of various occupations to try the instruments in order to be convinced of the practical utility of the telephone.

In Yokohama the writer gave a popular lecture to convey to the public an idea of the commercial and social uses of the telephone. In fact, we spared no pains to secure a satisfactory result in the new enterprise, but notwithstanding such efforts on our part, we only got about 70 contracts in Tokyo and 20 in Yokohama when we commenced the construction of the lines. The service was started in Tokyo and Yokohama in December of 1890, the number of subscribers at that time being about 200 in Tokyo and 40 in Yokohama. However, the actual opening of the exchanges and establishment of communication between the subscribers spoke far more eloquently to the public than any letters, newspapers or lectures, and before long our facilities were far behind the demand.

The growth of the telephone exchange business since 1890 may be seen from the following table:—

GROWTH OF TELEPHONE SERVICE

Year	Number of telephone exchanges	Number of telephone sub-stations	Miles of subscribers' lines (pole)	Miles of wires	Miles of overhead cables	Miles of underground cables	Nautical miles of submarine cables	Miles of toll lines	Miles of toll wires
1890	2	359	100	669	......	......	......	22	139
1895	4	2,913	388	4,826	1	......	......	46	410
1900	25	19,203	1,332	29,287	117	78	4	598	5,309
1903	46	36,700	1,669	40,593	198	173	4	901	7,571

The increase of traffic necessitated putting up more toll circuits, and about 100 miles of new line with about 1600 miles more wire are now under construction. On completion of the line, Tokyo and Nagasaki, 800 miles apart, will probably be put in direct communication.

When the changes were started in Tokyo and Yokohama, single circuits of No. 18 S. W. G. hard-drawn copper wire were arranged for subscribers' lines, the 100-wire standard switchboards of the Western Electric type and a modified form of the Gower-Bell telephone set with a battery for calling were employed, the toll lines between the two towns being metallic circuits of No. 12 S. W. G. copper wires. No. 18 copper wires were afterwards changed to No. 17, which is now the standard size of wire for subscribers' lines, except in the northern snowy districts, and the modified Gower-Bell set with calling battery has been changed to the solid back or Delville set with a magneto.

Small exchanges not having more than 600 subscribers are operated with the 100-wire standard switchboard, and for exchanges where more than 600 subscribers are to be connected, multiple switchboards are generally used. At present Tokyo has five exchanges, the largest of which contains 4000 subscribers and the smallest 1500, and each exchange is equipped with bridging multiple switchboards. In Osaka there are two exchanges, both of which are also fitted with bridging magneto multiples, having an ultimate capacity of 6300.

Reverse trunking is used between different exchanges in a town and also on short toll lines. Yokohama, Kobe and Nagasaki are also worked with bridging magneto multiples, these towns having only one exchange in each. Kyoto, our ancient capital, was worked with the old series-multiple switchboards, but an alteration to the relay switchboards, manufactured by the Western Electric Company, was effected in May last year, and since then the system is working satisfactorily.

Kyoto has no branch exchanges; it has an ultimate capacity of 6300, and the present equipment is 3000. The series-multiple switchboards are still in use in Nagoya. All other exchanges are being operated with the 100-wire standard switchboards, but some of them experience inconvenience at times in working, owing to increase of subscribers, and we anticipate supplying them with multiple switchboards.

In order to give an idea of the present situation of our telephone exchanges, the following figures are given for the seven towns where the exchanges are worked with multiple switchboards:—

MULTIPLE SWITCHBOARD EXCHANGES

Name of Town	Number of subscribers	Number of subscribers not yet connected	Public call offices		Population
			Ordinary	Automatic	
Tokyo	14,192	8,019	46	68	1,640,000
Osaka	6,481	3,481	28	10	930,000
Kyoto	2,413	3,303	13	9	380,000
Yokohama	1,464	517	22	14	300,000
Kobe	1,437	1,152	16	9	260,000
Nagoya	1,327	1,023	7	6	270,000
Nagasaki	742	359	4	1	140,000

A subscriber's set is furnished with either the solid-back or the Deville transmitter and is always equipped with an arrester. A desk set, artistically designed, is liked by some people and supplied, if required, on an extra payment of 6 yen per annum. Where the C. B. system is employed, the same type as the post-office wall set is in use, the transmitter being the solid back. Fuller's bichromate battery for the solid back and the Leclanché for the Delville are generally used.

The automatic telephone, which has come into use since 1899, is somewhat like the Grey instrument, and is so constructed that the operator is en-

abled to distinguish the kinds of coin put into the slot by hearing different sounds made by the coin in its sliding down along each chute. Fig. 1 shows a view of an automatic call box in the street of Tokyo.

No party lines are in existence at present, except a few telephone call office circuits in small villages. This system, however, has been often considered, with a view to meeting the pressing demand of the public for the telephone, but so far it has not come into use.

The actual number of toll line circuits amounts to about 100. In addition to that number 22 telephone circuits are formed by utilizing telegraph lines for simultaneous transmission, and 20 by duplex telephony or virtual circuit. Simultaneous transmission of telegraph and telephone was first experimented with in 1884 on the Van Rysselberghe system between Tokyo and Yokohama, but the experiment was not made with sufficient care and it ended in failure. The second experiment was conducted rather more carefully in 1886 by using the telegraph wires crossed and it resulted in a success.

When the telephone exchanges were started in Tokyo and Yokohama in 1890, all the lines connecting the two towns were specially constructed with copper wire transposed at intervals as a precaution against disturbance from external causes, and there did not exist much necessity of recourse to the telegraph lines. In 1894, duplex telephone circuits were tried between Osaka and Kobe, 23 miles apart, and were worked quite successfully. In order to actuate the indicators on the duplex circuit, the neutral points of the repeating coils were earthed, and by using the circuit so formed by earthing, direct signal current was sent so as not to cause disturbance to the conversation. The telephone lines between Tokyo and Osaka were opened to the public use in 1896. Combining these lines, which are 377 miles in length, duplex telephony was successfully applied.

In course of time telephone exchanges were gradually opened in various provincial towns, and this has enhanced the popularity of the telephone to a great extent, petitions for telephone facilities coming into the hands of the authorities from various quarters. This brought up the necessity of opening telephone call offices first in those places which did not possess telephones, and to save money, existing telegraph lines were used. At present about 1000 miles of telegraph wires are worked simultaneously for the telephone.

The flat rate system is adopted in all towns. The charges are as follows:—

	Per Annum
Tokyo and Osaka	66 yen
Yokohama, Kobe, Kyoto and Nagoya	54 yen
Other smaller towns	48 yen

These are for subscribers located within the town limits. Those living in the vicinity beyond the town limits, but within a certain telephone area specified by the government, can be connected to the exchange by a payment of 10 yen per 120 yards or less, for construction of a line beyond the city limits, and a payment of 2 yen per annum per 120 yards or less beyond the city limits as additional subscription.

Interurban lines are charged for according to the distance and for a conversation not exceeding 5 minutes. The basis of the toll rate is approximately as follows:—

Up to 5 ri (one ri is nearly 2.5 miles)	20 sen
Up to 25 ri	25 sen
For each ri beyond 25 ri	1 sen

In a small provincial town or in a village which is specified by the government, and which is connected by a toll line to any other town having an exchange, people can be connected at their own expense to the post-office of the specified town or village in order to make use of the toll line from their house.

Small switchboards are provided and worked in such post-offices by the government, and the subscribers have to pay to the government 24 yen per annum for the service as well as for expenses for the maintenance of the line, the instrument, and the like, which, by the agreement, must be entrusted to the government. Seventeen such special exchanges are now working.

The financial condition of the telephone undertaking is a satisfactory one, as shown by the following table:—

TELEPHONE FINANCIAL STATISTICS

Year	Expenditures in yen	Receipts in yen	Capital in yen
1895	91.548	142,616	....
1900	964,899	1,533.417	....
1903	1,230,592	2,670,631	12,618,658

The work is partly suspended for the present, owing to the outbreak of the war, but when the peace is restored and commercial activity is resumed, it will, no doubt, be continued to meet the public requirements.

Notes from the Tour of the Visiting Foreign Electrical Engineers

EN ROUTE TO ST. LOUIS VIA MONTREAL, SEPTEMBER 5-12

By WM. MAVER, Jr.

On Monday morning, September 5th, beautiful weather favored the members of the American Institute of Electrical Engineers and the visiting electrical engineers from abroad to the number of 600 in all, on the tour of electrical power stations of New York city, as the guests of the New York reception committee of the Institute. The party convened at the City Hall Station of the Interborough Rapid Transit Company, where a special train of eight cars, five of composite wood and steel and three of all-steel construction, was awaiting them. Owing to the rumors of an impending strike of the motormen of the Elevated Railroad, in which case it has been stated the subway would be opened to traffic at once, a curious crowd of onlookers gathered around the delegates, evidently in the belief that they were somehow concerned in this strike question. The party were received by Messrs. L. B. Stillwell and H. G. Stott, of the Interborough Company. The start was made at 9:58 o'clock, and the station at Columbus Circle, Fifty-ninth street, was reached at 10:25 o'clock, no stops having been made during the trip, but the train was run at a slow speed in order that the visitors might have a better opportunity to observe the construction of the subway. This trip was memorable from the fact that it was the first train load of passengers that had passed through the subway.

From Fifty-ninth street station the party, among whom were many ladies, walked over to the Interborough Rapid Transit Company power station at Fifty-eighth street and North River. This large station, which, when complete, will consist of 8 generating units of 5000 kilowatts each, was viewed with great interest by all, the right-angle connection of the high and low pressure 8000 horse-power engines attracting the special attention of the visitors. Three of these units were ready for operation and were kept turning over during the visit of the electrical engineers.

At this point the visitors boarded the steamer "Nassau" and the "Western Union" for a trip of inspection to the other large power houses on the Hudson and East Rivers. Shortly after leaving the Fifty-eighth

street pier, the New York City fire boat "A. S. Hewitt" gave a highly interesting exhibition of its capacity for pouring streams of water from its 10 or 12 nozzles, jointly and separately, this presenting a spectacle that evoked exclamations of astonishment and delight from the spectators. On proceeding, the steamboats ran close inshore, affording an excellent view of the soldiers' and sailors' monument and Grant's tomb en route.

Passing through the Ship Canal to Harlem River, a stop was made at the Kingsbridge power house of the New York City Railway, where the members of the party were met by the chief engineer of the company, Mr. M. G. Starrett, who conducted them through the station, pointing out its various features of interest. At this stage of the tour a much relished collation was served to the guests, the early start and the bracing river air having whetted the appetites of every one.

It was originally intended to visit the Ninety-sixth street station of the same company, but owing to the unavoidable delays in the trip it was necessary to forego this part of the programme. The boats were then headed for the Seventy-fourth street station of the Manhattan Elevated Railroad Company on the East River, after an inspection of which, the party proceeded to the Waterside Station of the New York Edison Company, where they were met by Mr. J. W. Lieb, Jr., the president-elect of the American Institute of Electrical Engineers.

The 5000-K. W. generator operated by a Curtis steam turbine was the center of attraction at this station. The turbine is arranged vertically and the generator is mounted on the upper end of the shaft, as in the case of the water turbines of the Niagara Falls Power plant. The economy of space gained by the use of the steam turbine as compared with the reciprocating steam engine of corresponding power was a subject of frequent comment by the visitors. At the Waterside Station the visitors dispersed, the foreign delegates being conveyed to their respective hotels in automobiles at four P. M.

In the evening the delegates attended a reception and banquet given in their honor by the New York reception committee, at the Waldorf-Astoria, at which short addresses of welcome were made by Messrs. Arnold and Fornes, which were responded to by Messrs. Gray, Arcoli and Von Siemens. A short address of welcome by Prof. Elihu Thomson, representing the International Congress, was acknowledged by Prof. John Perry. Mr. C. A. Coffin spoke on behalf of the electrical industries of the United States, and Mr. J. W. Lieb gave an address of welcome on behalf of the various reception committees. The delegates were outspoken in their admiration of the beauty of the decorations, the excellence of the service, and the general conduct of the affair which was in charge of Mr. C. W. Rice, chairman, and his colleagues, Messrs. C. A. Terry, L. J. Magee, G. F. Sever, C. Townley, and T. C. Martin.

The visit on Tuesday, September 6th, to the works of the General Electric Company, at Schenectady, was one of enjoyment. and profit. On walking through the extensive grounds occupied by the 85 or 90 large buildings of the company, it was difficult to realize that less than 15 years ago there was but one building in that locality devoted to manufacturing purposes, and that the ground on which the present works have been built was then mostly swamp land.

One of the most attractive features of the works to the visitors was the operation of the Curtis steam turbines in the new power house building, No. 85, which is equipped with eight 1500-K. W. generator units. Another building of much interest was that in which the steam turbines are being constructed, a tour of which afforded the visitors an opportunity of seeing the manufacture of this comparatively new type of steam engine in its various stages of construction.

While these buildings were perhaps of more than usual interest, the buildings devoted to the construction of massive transformers, the manufacture of cables, armatures, searchlights, and others too numerous to mention in detail, were also closely observed by the visitors.

The trip to Ballston from Schenectady on special electric cars was greatly enjoyed in the evening, the beautiful Mohawk river presenting a charming spectacle in the twilight. One of the electric cars on this road was equipped for experimental purposes, with the new compensated single-phase motors of the General Electric Company, and by the raising of a trap door in the floor of the car an opportunity was given to the delegates to view one of the motors in operation. These motors will operate with single-phase alternating or with direct current. Hence direct current may be used on the car in cities and alternating current in the country or suburbs. In the case in point, direct current at 600 volts was used up to the city limit, when connection was made with a 2500-volt single-phase alternating current overhead circuit, which was stepped down to 400 volts by a transformer on the car. The change from direct to alternating current is made by means of a commutating oil switch on the car. There are two motors on this car, in series, each taking 200 volts alternating current or 300 volts direct current.

In the vicinity of Montreal, on September 7 and 8, the sightseers, among many other objects of interest, had the privilege of observing two different types of water-power-operated electric plants, one of which may be termed the low pressure and unlimited volume of water, as at Chambly and Lachine, and the other, high pressure and comparatively limited volume of water, as at Shawinigan Falls. At the Lachine power house, 6 miles from Montreal, the working head is between 16 and 17 feet and each unit is made up of 6 vertical turbines connected to a 750-K. W., three-phase, 5000-volt generator, the present total output of the plant being about 8000 K. W., transmitted at high pressure to Montreal.

At Chambly, 15 miles from Montreal, there is another low-pressure hydraulic plant, where the working head is 33 feet and the output about 25,000 K. W. At Shawinigan Falls the working head is 150 feet, with a calculated capacity, when fully utilized, of 100,000 H. P.

It is a little surprising that notwithstanding the numerous sources of water power surrounding the city of Montreal, much of which is utilized, the rate for general electric lighting and power is considerably higher than that charged in many other cities where steam power is used.

This may be partially due to the fact that the supply of electricity and gas in Montreal is in the hands of one company. The comparatively high rate charged for power here cannot be laid, as it is in some other cities, to the cost of underground cable and conduit construction and maintenance, inasmuch as the circuits throughout the city are mostly overhead, and it must be added, the overhead construction does not appear to be at all points costly or ornate. Another feature that is perhaps peculiar to Montreal is that consumers of electricity are charged at the rate of from $1 to $3 per annum for the use of meters on their premises.

A notable feature of the operation of the Montreal electric light and power system is the unusually high load factor obtained in that city, the average load factor per annum being 75 per cent. In the majority of American cities the load factor is usually under 50 per cent. and in many cases it is

less than 30 per cent. This excellent showing in Montreal is brought about by offering to large users specially low rates for electric power not used between the hours of 4 P. M. and 7 P. M. during the winter months. In consequence of this arrangement a number of factories employing electric power shut down at 4 o'clock in the afternoon and others use the power after the prescribed hours.

The fact that a considerable portion of the country between Montreal and Labrador rises almost abruptly from the north shore of the St. Lawrence River to a height of one or two hundred feet and then rises more gradually for 400 or 500 miles in the Laurentian Mountains, would seem to provide the natural conditions for an excellent supply of water power. And this is the case, for between Montreal and Quebec—a distance of 175 miles—there are at least seven water falls having an estimated low water capacity ranging from 1500 to 100,000 H. P., to say nothing of innumerable water falls of minor importance.

Among the most important of these natural sources of power are the Maskinongé Falls, about 40 miles from Montreal, the Shawinigan Falls of the St. Maurice River, 84 miles from Montreal, the Montmorenci Falls, the Ste. Anne Falls, and also the Seven Falls a few miles from Quebec. Of these the Shawinigan Falls are by far the largest in point of volume, the St. Maurice River being over 400 miles in length and draining a territory of more than 18,000 square miles. The amount of water flowing over the falls averages approximately 26,000 cubic feet per second. The river at this point drops about 150 feet in less than 200 yards, and, as previously remarked, it is estimated that 100,000 H. P. will eventually be developed here. This, it may be noted, is equal to the horse-power developed by the Canadian Niagara Power Company at Niagara Falls.

The falls of Montmorenci are very picturesque, having a sheer descent of 260 feet, but the volume of water is limited, furnishing at present not much more than 5000 horse-power.

The Maskinongé Falls are nearly 140 feet in height, and have a capacity of 1500 H. P., but at present are used merely as a source of power for a small saw mill. The Ste. Anne Falls and the Seven Falls have not yet been developed. They have recently been surveyed, however, and work will shortly be begun upon them by the Quebec Electric Company. The Seven Falls will have a working head of about 375 feet, and will develop nearly 15,000 H. P. at low water. The Ste. Anne Falls will develop 10,000 H. P.

The trip to Shawinigan Falls was participated in by nearly one hundred members and visitors, two cars of the Great Northern Railway being comfortably filled. En route a stop of ten minutes was made on the trestle over the ravine at Maskinongé Falls, from which point a delightful view of the silvery falling water was obtainable. Two miles outside of Shawinigan a majority of the party temporarily left the train to visit the plant of the Shawinigan Carbide Company, in which much interest was manifested. The power for this plant to the extent of 3600 K. W., is supplied from the power house at the falls.

At noon the delegates partook of a hearty dinner, after which the falls, the chutes down which the spruce logs used in the wood pulp industry are carried past the falls, and the various power houses were inspected by the visitors, who were escorted over the route by Mr. Wallace C. Johnson, engineer; Mr. Beaudry Leman, resident engineer; Mr. A. J. Gorry, manager of the Shawinigan Water & Power Company; Prof. R. B. Owens, Messrs. W. B. Warren and other officers and members of the local reception committee.

The electric power now developed at Shawinigan Falls is equal to about 27,000 H. P., of which about 11,000 H. P. are used in the vicinity of the falls, the remainder being transmitted to Montreal and intermediate towns, or shortly will be.

The Northern Aluminium Company here develop 2000 K. W. direct current, in their own power house. This power is conveyed to the reduction house of the company, a distance of 200 feet, at 300 volts, on a two-wire metallic circuit composed of 200 aluminium wires, three-eighths of an inch in diameter. These two hundred wires are bunched together and are strung over the cross-arms of ordinary wooden poles without other insulation. The positive and negative legs of the circuit are supported on separate parallel pole lines, about 15 feet apart.

A feature of the transformer house of the Shawinigan Falls Water & Power Company that attracts notice is the simplicity of the switching apparatus for the 50,000-volt transmission line to Montreal. There is no switch-board in the ordinary service, the current passing from the high-tension terminal of the transformers to the bus-bars, thence through long break knife switches, about 18 feet from the floor, and operated by long wooden poles in the hands of the attendants.

The wires, suspended in mid-air, then pass through static interrupters and thence out of the building to the poles of the transmission line, through the centre of a thick plate of glass set in circular tiling in the wall, there being a separate opening in the wall about 2 feet in diameter for each wire.

The transmission line consists of three aluminium cables, each of which is composed of seven No. 7 aluminium wires. The poles are of wood. In numerous places near the lower end of Montreal Island, where the Ottawa River frequently overflows its banks, and inundates the country for a considerable distance, the poles are set in log cribs about 8 feet square and 5 feet high filled in with stone. A second transmission line, which will convey 10,000 H. P., is now under construction from the falls to Montreal. All the electric power thus transmitted to Montreal is delivered to the Montreal Heat, Light & Power Company.

The returning special train left the falls at 4 o'clock, and after a record run reached Montreal at 7 o'clock. Those of the party who remained in the city were taken in charge by the local committee under the direction of Mr. H. D. Bayne, and visits were made to the grounds of the Montreal Hunt and the Lachine Rapids Hydraulic & Land Company's plant, over which they were shown by the officers of the company.

The circular tour train left the Windsor Station of the Canadian Pacific Railway in two sections, the first at 8 P. M., the other at 8:30 P. M., en route for Buffalo and Niagara Falls, the Montreal local reception committee and a large number of the citizens of that city being present to give the delegates a fitting "send off."

The First 40,000-Volt Power Transmission in Europe

THE 40,000-volt water-power transmission between Gromo and Nembro, in Italy, the first line in Europe to be operated at such high voltage, was opened early in July, and has given every satisfaction since. The present scheme only includes the transmission of 2000 H. P., but a further 2000 H. P. from a neighboring waterfall is to be transmitted along the same line later on. The distance is 20 miles.

Indianapolis, Ind., it is said, within a year will be lighted with electricity brought a distance of 160 miles from the dams of the Indiana and Michigan Electric Company at South Bend, Ind.

Mathematics in Engineering

By THORBURN REID

FOR many years a controversy has raged between the so-called "practical engineer" and the "mathematical or theoretical engineer," a controversy which has its counterpart in many other branches of professional as well as business life, and is intimately connected with the question of the value or worthlessness of a college education to the man who has his way to make in the world.

Some one, I think it was that original mathematical genius, Oliver Heaviside, who was wont to scatter mirth-provoking witticisms at rare intervals through the pages of his most abstruse mathematical treatises, once coined the term "practician" to designate the man who despised mathematics and theory and worked by experience and "rule of thumb." The word avoids some circumlocution and has a definite meaning, and I shall, therefore, use it in what follows. Also, if I may be allowed to coin a new word myself, or rather to extend the meaning of the old one to a class to which it has not commonly been applied (which was in reality what Heaviside did), I shall use the word "precisian" to denote the mathematical or theoretical engineer.

The question, then, is not "is mathematics useless?" for no sensible man would ask any such question regarding mathematics when confined to its own proper sphere, but "is mathematics of value to the practical working engineer who must accomplish actual, useful results—who must do things?" The question has so far been approached very largely from the empirical side; the "practician" has cited numerous cases coming under his observation where the use of mathematics has resulted in failure or disaster, and the "precisian" has cited cases where the use of the rule of thumb method or the lack of mathematics has led to the same result. Such reasoning, however, can apply only to the experience of the man who employs it and should obviously not be used to formulate a general law, especially when it is remembered that human nature is prone to see only those facts which chime in with preconceived ideas. A study of the nature and use of mathematics, in connection with engineering problems at least, will serve to show even more clearly to what fallacious results such reasoning may lead. The practician's idea of the nature and use of mathematics was once well expressed by Mr. T. D. Lockwood, in a comment he made on a very mathematical paper read before the American Institute of Electrical Engineers, when he said:

"Mathematics, however valuable it is (and no one can doubt its value if properly used), is too frequently like a very well fitted and extremely costly machine shop, filled with the highest order of machine tools owned and operated by some person who, with all the necessary skill to work them, employs his skill and the time of the machine's in doing nothing else but making more machines of a still more costly and intricate nature."

Mathematics, as Mr. Lockwood so neatly puts it, does consist of fine, accurate tools, but these tools must be used by workmen who are experts in managing them or the job will inevitably be spoiled. It has also been described as a language that must be learned, but the writer has always preferred to call it "short hand reasoning." According to this conception the letters and symbols used in mathematical analysis are simply abbreviations for words and phrases, just as the pot hooks of stenography are abbreviations for words, sounds and, in some cases, phrases.

The principles upon which the processes are based by which these letters and symbols are combined into equations and by which the equations are solved in order to reach a correct conclusion from the data supplied, are the ordinary principles of human reasoning; that is, reasoning from cause to effect and from effect to cause just as in stenography the words represented by characters are combined into sentences in accordance with the laws of grammar and the usages of common speech. But stenography, as well as mathematics, is a useless tool to the man who has not studied it and become expert in working with it.

Much of the prejudice existing among practicians against mathematics is caused by the mathematicians themselves, and especially by those of them who teach mathematics. Unlike the stenographers, however, they unconsciously grow to think of the solution of a problem, not as a means to an end, as they should, but as the end itself.

It is natural, perhaps even inevitable, that this condition should continue, at least to a very large extent, for the reason that for the teacher as well as the student the solution of the problem is usually as far as he can go and it is seldom that either of them has an opportunity to observe a practical application of the results obtained or to check them by comparison with the results of tests.

Another very serious defect in prevailing methods of teaching and a defect that seems as inevitable as the one mentioned, is the custom of giving the student his data in numerals, all nearly arranged for insertion into equations.

These two defects militate strongly against the practical use of mathematical analysis in two widely different ways. The latter often leaves the novice helpless to apply to practical problems the knowledge he has gained; the former leads to costly and disastrous mistakes which discourage him from again attempting to use the same means.

Imagine the average graduate of a technical college, standing, say, on the top of some river side cliffs, asked to determine roughly and without other instruments than a 2-foot rule and a watch, the width of the river at that point, a problem which was put to the writer as a boy and easily solved mainly because of previous training in determining the heights of trees and other similar problems by triangulation. I moved back from the edge of the cliff until my eyes, the cliff edge and the opposite shore of the river were in line, and measured the distance from the cliff edge to where I was standing and the height of my eyes above the ground. I then threw stones out as nearly horizontally as possibly, noted the time required for them to reach the surface of the river and calculated from that the height of the cliff above the river; the rest was a simple solution of similar triangles, which gave a result surprisingly nearly correct, considering the exceeding inaccuracy of the means at hand for making measurements.

The ordinary way in which such a problem would be given to a student would be something like this:—

"A man stands on a cliff overlooking a river, with his eyes, the cliff edge and the opposite bank of the river in line, his feet being on the same horizontal plane with the cliff edge. He stands so many feet back from the edge of the cliff, his eyes are so many feet above the ground and the height of the cliff is so many feet; what is the width of the river?" The hardest part of the problem, the only part in fact that presents any difficulty, is solved for him beforehand.

It has certainly been my experience, and I think every engineer who is at home in the use of mathematics will agree with me, that by far the greatest difficulty lies in formulating a basis for analysis; that is, in determining what data can be ascertained by tests or measurement to serve as a basis for analysis. Usually when this has been properly done, the problem may be considered as solved, and in this branch of the subject the student, as a rule, gets little or no practice or instruction.

The same example may serve to illustrate the other defect mentioned. The student seldom has a chance to connect the numbers, figures and symbols with the actual measurements and objects they represent. To him they have no concrete meaning except as symbols and figures and to use his solution practically, as, for instance, in determining how long it will take him to row across a river is an idea that is often new and strange.

Further, he has no idea how far he can trust the result of his analysis, has had little training in judging the accuracy of his data, since in the main they are given to him cut and dried, and he is thus apt to consider his results as accurate as are the processes by which alone he has arrived at them and he, consequently, often acts on this conclusion with disastrous results.

I am not here concerned with the remedies of such defects in teaching, nor with the defects themselves, except in so far as they throw a side light on the subject under consideration by showing not what is the proper sphere of mathematics in engineering, but why so many engineers feel that they have no place in it at all. It may be also well to add that I do not hold these defects in teaching to be universal, but that they are the rule, although there are doubtless many shining exceptions.

The problems confronting the engineer involving the use of mathematical analysis or formula may be roughly separated into two classes—those which do and those which do not involve original investigation.

Few engineers are called upon to attack problems of the former class and fewer still are capable of solving such problems. The use of mathematics is generally unavoidable in such cases, unless the engineer be that rare genius—the natural mathematician.

Some one defined genius as "infinite capacity for taking pains." Like most such epigrammatic statements, it is but half the truth. Without some special aptitude for the work in hand no amount of painstaking labor will avail to accomplish the results that lift the genius high above his fellows.

Inventors often are natural mathematicians, that is, they are able to solve the problems that arise by attending directly to the elements of the problem itself without recourse to mathematics, and the clear and luminous pictures they are thus able to form in their minds of the interrelations of all the various factors affecting the problem enables them to predict effects and accomplish results astounding to the plodding mathematician who follows slowly and laborously in their footsteps.

As an example of this faculty, Mr. William Stanley, Jr., once asked the writer to solve mathematically a problem whose solution would be expressed as a curve. The long and intricate analysis covered several sheets of paper with cabalistic symbols, signs and equations, and before it was finished Mr. Stanley came in and asked if I had reached any result. I replied that my analysis gave the curve as a straight line, but that I would have to check up the work before being sure of its correctness. He said, with perfect confidence, "That is wrong," and, without any hesitation or calculation, he drew with a pencil a curve on a sheet of section paper and said "That will be about right." I checked over my work, found a mistake and corrected it, and saw that the values given by the correct equation differed scarcely 10 per cent. from the curve Stanley had drawn.

As an example of this same faculty in the case of an eminent engineer, rather than an inventor, Mr. H. F. Parshall once instructed me to design an alternating-current generator whose size and speed differed widely from anything we had previously designed or made. When I had finished the design, I took it to him and merely detailed its general features and the methods of calculation and then took it to the cost department for an estimate of cost. The result so surprised both myself and the head of the cost department that we went back to Parshall, and without telling him what we had found asked him what he thought it should cost. He turned and looked out of the window a moment, then answered "eight dollars a kilowatt." We had it eight dollars and three cents a kilowatt.

Of course so close an agreement as this was a mere coincidence, but it was only one of many instances where his apparent guesses were practically as accurate as the results of detailed calculations.

Both of these examples might seem at first sight to be arguments against the use of mathematics even in original investigations, but it must be remembered first that genius of the order possessed by these two men is given to few engineers and secondly, they both recognized the necessity of having their conclusions verified by the certainty and accuracy of mathematical methods.

The ordinary engineer, who is not a genius, must either use mathematics in problems of this class or must employ the slower and usually much more costly methods of trial and failure.

On the other hand, the novice in attacking such problems is apt to rely too much on the results of his analysis. It is never possible to have absolutely accurate data on which to base an analysis, and, what is far more important, it is seldom possible to take account of every factor that may affect the result.

This latter is an especially frequent and insidious source of error when mathematical analysis is employed for the reason indicated, that the mind is taken away from the actual physical facts of the case and concentrated upon the symbols employed and upon the means of solving equations. For this reason the only safe way to avoid such errors is to refer back every important equation reached in the course of the analysis to the physical facts it represents. In other words, retranslate into words the symbols of the equations and see if the law or fact it represents is a reasonable deduction from the premises, whether the inaccuracy of the data or the omission of certain factors of the problem which at the beginning of the investigation seemed unimportant, might not at some stage of the analysis be found to have a much greater bearing on the result than appeared probable at the start. Such a practice also serves the important purpose of bringing to light errors in the processes of the analysis itself.

In fact, no important original engineering work should be based on such analysis unless it be possible to follow through the whole line of reasoning represented by the analysis. This thought relegates mathematical analysis to what is its proper sphere in such investigations, that is, its mechanical processes are a powerful instrument for directing the mind into the cor-

rect line of reasoning, and when reasoning, following the steps of the analysis, has shown it to be correct, the final equations can be used to furnish exact numerical values or quantitative laws.

This apparent lack of confidence in the results of such analysis is not because its processes are not perfectly exact or because there need be any great probability of error, for neither of these things is true, but because nature does not provide material objects formed with the same exactness as are their imaginary representatives in mathematical analysis, and for the far more important reason that even with the use of every available aid toward the predetermination of final results, it is almost impossible in original work to think of and allow for the effect of every factor that may enter the problem and affect the final result.

An equation based on certain assumptions will, if the analysis be correct, be an exact statement of what will result if conditions are in strict accordance with those assumptions, and if they include all the factors affecting the result; but it gives absolutely no information as to the accuracy or completeness of the assumptions themselves unless it, as well as the steps leading up to it, be referred back to the physical conditions it represents. That is, while the analysis itself is an absolutely exact process, the assumptions on which it is based can never, in the nature of things, be exact, but must always be more or less approximate representations of the actual conditions. It is this limitation that must be always kept in mind by the engineer who is engaged in original research if he wishes to avoid humiliating and often costly mistakes.

When the pure mathematician who is without practical engineering experience has finished his analysis, he is apt to consider his task ended, his goal achieved, since he usually has neither the data necessary to check his results nor facilities for testing them by experiment. The engineer, however, if he be wise, will compare his results with facts, if he has them, or, if not, will, if possible, make experiments to determine the accuracy of his deductions before relying on them in any important engineering work.

I was once discussing with Dr. C. P. Steinmetz, one of the foremost mathematical electrical engineers, the results of a mathematical investigation he had been making. I stated that his equations did not agree with some facts brought out by experiments that I had made.

He promptly replied: "If the facts do not agree with my equations, the facts are wrong."

This paradox seems at first sight to run directly counter to what I have just been saying, but it is really an inverted application of exactly the same principles. The thought in his mind was doubtless, "My equations are correct deductions from the assumptions I made. If your facts do not agree with my equations, then the conditions under which the experiments were made were not such as I assumed for my analysis."

Engineers who know his achievements will, without dissent, accord to Dr. Steinmetz the privilege of expressing such confidence in his deductions, as was shown by their acceptance without comment of a statement made by him in his paper read before the American Institute of Electrical Engineers in which he disclosed his celebrated one and six-tenths power law of magnetic hysteresis. This law was admittedly entirely empirical, a large number of tests having been made, and the results plotted in the form of curves. A number of different equations were then tried until one was found that gave curves agreeing closely with those obtained by test, the two sets of curves being plotted on the same sheet to show the closeness of their agreement.

Steinmetz then said that if any value was found to be very much out of the curve connecting the other values, it was stricken out as evidently erroneous, not considering it worth while to determine whether it was wrong reading of any of the instruments or a mistake in the calculation. Such a statement coming from an ordinary engineer would have been considered as tantamount to saying: "I picked out such points as confirmed the practical accuracy of my equation and discarded the rest," thus basing the equation on the points and then the points on the equation. Doubtless the engineers present felt that Steinmetz reasoned justly that the curve of hysteresis was a smooth one and that, if a point here and there was considerably off the curve drawn through the other points, the probabilities were so overwhelmingly in favor of an error in the readings that it was not worth while to repeat the test to detect the error, all of which only goes to show that the master is not subject to the same limitations as are his disciples.

This law, first disclosed by Steinmetz, has since been tested probably thousands of times and found to be accurate enough for most purposes, and this leads us to the second class of problems which the engineer is called upon to solve—those which do not involve original investigation but rather the application of equations previously deduced by original investigation and subsequently tested and found sufficiently accurate for the ordinary purposes of the engineer.

It is in this field that the battle between the precisian and the practician is mainly waged, and, as in most such controversies, the greater part of the fighting is futile and beside the mark.

Lawyers, whose profession is preeminently the practice of controversy, have a process technically called "special pleading," the function of which is the elimination from the discussion of all considerations which are irrelevant or immaterial, and a clear, unmistakable definition of the exact question at issue. This process is a wonderful time and labor saver and can, with great advantage, be applied to all controversies whether legal or not. In fact, such a clear statement of the question at issue often decides it without further controversy.

In order to define the question at issue between the practician and the precisian in regard to the utility of mathematics in engineering, we must first understand clearly what the engineer wishes to accomplish; and, second, the means by which he attains his ends.

The main purpose of the engineer's labor is the production of structures of material utility to mankind by a combination of the properties of the materials of nature that are at his disposal.

The engineer with his mind centered on the objects themselves is often unconscious of the fact that it is not primarily these objects, but rather their properties, which he employs. Each material of construction is to the engineer in reality but a bundle of properties which can not be dissevered. Some of these properties are useful for his purpose, some are useless or even detrimental, but all, whether useful or detrimental, must enter into the combination of which the material to which they belong forms a part. The engineer, then, who posseses the most complete and accurate knowledge of the properties of the materials he must employ, has the most ample resources and can employ them with the greatest precision. There can be no controversy as to this statement, nor as to the further statement that, other things being equal, he is the best engineer who possesses the most ample resources and the most accurate knowledge of the properties of materials.

In order that this knowledge may be used to the best advantage, it should be in such shape as to be quickly and easily applicable to the solution of the problems in hand. The more quickly and easily this knowledge can be applied, or to put it a little differently,

the more of this kind of knowledge the engineer has, which is quickly and easily applicable, the better.

The engineer may have certain qualities of mind, of temperament, or of character which have a much more important effect on his efficiency as an engineer than the amount of availability of the knowledge he posseses; but with these we are not at present concerned, except in so far as his methods of work may possibly have a modifying effect on such qualities. On the contrary we are concerned with the knowledge he possesses and with the methods of his application of that knowledge in his work. The more complete and accurate this knowledge of the properties of materials is, the better, as a consideration of the form of this knowledge will make clearer.

Most of these properties must be expressed quantitatively. Strength, cohesion, friction, weight, heat, or electrical conductivity and many other properties are expressed by numbers. The so-called laws of nature, which are, in reality, but statements of properties of matter, are not, however, stated in numbers simply, but as relations existing between two or more properties of matter.

Now if these numerical values expressing the degree of strength, weight, etc., which are properties of a particular material, are used in engineering work, a certain amount of calculation is necessary, and if the relation existing between the properties of matter are to be used, they must be expressed in formulæ, whether the quantities entering the formula are represented by words or by symbols. Here is the crucial point of the controversy. The practician contends that his judgment, trained by long experience, will enable him, in many instances at least, by mere inspection to approximate more closely and surely the correct proportions than will the elaborate calculations of the precisian.

The precisian contends, on the contrary, that there are no instances or at most very few, where more precise methods will not give better results.

There can be no controversy, however, as to the fundamental thesis that, provided all the factors affecting the work in hand are taken into account, provided the constants on which the calculations are based are reasonably accurate and proper allowance be made for their inaccuracy, and provided no mistakes are made in the calculations, more accurate proportions will result than could be attained by the use of the best trained judgment by mere inspection. This is to say that the methods of the precisian, properly used, produce more accurate and efficient proportions than do those of the practician also properly used. As to whether there is any property inherent in the methods of the precisian that militates against their proper use to such an extent as to make them less accurate and reliable than the methods of the practician, I am not here concerned, but I may perhaps be pardoned if I turn aside to point out one fallacy in the common argument on this point. This argument is that the precisian makes more mistakes than does the practician, and that, therefore, the methods of the precisian make him more liable to err.

Statistics have been grosssly libelled as being notorious liars. It is not the statistics that are liars, but the people who draw improper or unwarranted inferences from them. Admitting, for the sake of argument only, that the precisian makes more mistakes than does the practician, it does not by any means necessarily follow that his methods must be made to shoulder the responsibility, for there is another possible explanation of the fact, if fact it be, and one that is more inherently probable; that is, that the class of mind that naturally tends towards the use of mathematics in engineering is apt to lack certain qualities essential for success in practical work; but this is entirely aside from the value of the method itself and is a question only of the efficiency of the man.

It is at least possible, even probable, that most precisians would be poorer engineers without their mathematics and that facility in the use of mathematics would increase the usefulness and efficiency of the practician. Since there are thus two possible inferences to be drawn, and since it is not feasible in practice to separate the method from the man, the question as to which of these two inferences is correct can not be decided by two contrasted methods, and this article may be considered as an attempt to clear up one field of the controversy by defining the sphere of mathematics in engineering and by pointing out certain sources of error which should be avoided.

I have said that precise methods, properly used, produce more accurate and efficient proportions than can be attained without them, but such accuracy is sometimes of minor importance as compared with other considerations entering the situation. A story is told of Captain Mason, chief of construction in the Confederate Army under General "Stonewall" Jackson, that he was once ordered to build a bridge over a certain stream just as soon as it could possibly be done, and that plans would be furnished him by the engineers in a day or so. A few days later General Jackson asked him if he had received the plans for the bridge.

"No, sir," replied the grizzled veteran, "I've seen none of their pictures, but I've built the bridge and you can cross it when you are ready."

That was clearly a case where the engineer's calculations were out of place, as the bridge was amply strong for its purpose, probably much stronger than was at all necessary; but under such conditions economy was a minor consideration while speed was all important. It is probable that Captain Mason could have built as good a bridge in the same or even less time if he had possessed in addition to his long experience as a practical bridge builder the ability of a trained mathematician and the bridge would doubtless have been built with less material and in less time if the engineer's plans for it had been immediately available.

The main advantage of formulæ in such problems lies in their certainty and exactness as compared with the best of guess work commonly called rule-of-thumb; but these formulæ must be used with judgment and especially with understanding. It will not do to go to some engineer's hand book extract a formula that seems to fit the case and, applying it to the case in hand, use the values it gives, blindly and without understanding. This is to court disaster, for, while correct results may be attained by good luck, sooner or later a mistake will occur. The formula itself, as well as the method of derivation and the assumptions on which it is based, must be understood. This does not mean that the engineer must be capable of deriving the formula or even of understanding the mathematical processes by which it was derived, but he must understand the reasoning those processes represent, for it is only thus that he can understand the reasons for the presence of the various factors the formula contains, and and be in a position to allow for other factors which may affect the problem in hand and not be present in the formula.

Consider, for instance, the formulæ for falling bodies given in most handbooks. There is usually no mention of resistance of the air as affecting their accuracy, and yet, if the stone I threw off the cliff top, mentioned earlier in this article, had fallen a few thousand feet instead of a few hundred, or if a light piece of wood had been thrown instead of a stone, the air resistance would have made a serious error in the calculated height of the cliff. A knowledge of the fact that these equations were derived from the observation of bodies falling in a vaacum would be a safeguard against errors of this kind.

Nothing will guard against such

errors except a complete understanding of the formula and of the assumptions and principles upon which it is based. The engineer can otherwise do no better work with them than could an unskilled laborer with machine tools. He must know his tool, its ins and outs, the inter-relation of its parts and the function each part performs toward the final result.

Further, he must consider the reasonableness of the values the formula gives. It sometimes happens that a formula which is sufficiently accurate over the range of values ordinarily found in practice will yield wildly inaccurate results in extreme cases; or the engineer may forget that some factor affecting the problem in hand is not included in the formula, and this points to another liability of error that is inherent in the use of mathematics, already noted in connection with problems involving original investigation —the mind is taken off the realities of the case the actual materials used and the conditions to be met, and is concentrated upon symbols and signs which give no indication of the correctness of the results obtained.

In order to minimize the liability to error from this cause the engineer should compare the proportions thus obtained with those which his judgment trained by experience would lead him to expect, and if the two differ widely he would be wise, if he has the time, to trust to the correctness of neither conclusion until he has reasoned out why they differ and thus determined which is in error.

To sum up then, mathematical analysis can not with safety be used by the engineer who has not been trained to its use in practical work. Even then he must not rely too much on the results obtained by processes but must continually refer back its conclusions to the physical facts they represent. In other words, the processes of mathematics are not to be used to supplant his reasoning, his common sense, his trained judgment, but to aid these by broadening his resources and increasing the accuracy of the knowledge which his other powers of mind will thus enable him to use to better effect.

Carborundum firesand is an electric furnace product formed at a temperature of between 6000 and 7000 degrees Fahrenheit. It is derived from two of the most refractory materials known to the metallurgist, being chemically a compound of carbon with incompletely reduced silica. One of the most successful applications of carborundum firesand and one of special interest to the foundryman is its use in the construction of brass furnace linings.

The Cooper Hewitt Lamp in Electrotherapeutics

THE part played by the Cooper Hewitt mercury vapor lamp in the successful treatment of tuberculosis of the larnyx was described in a recent issue of "The Medical Record." The treatment consisted in the exposure of the patient to X-rays once in every four or five days, with an exposure to the rays of the Hewitt lamp in the interval.

The high-frequency current employed with the X-rays was obtained from the 110-volt, direct current in the street service by means of a liquid interrupter. This consisted of a beaker of tough porcelain with three or four pinholes near the bottom; this is set in a large jar full of dilute sulphuric acid, and a lead plate connected with one wire dips into the acid outside, while a lead ring from the other wire dips into the acid outside of the beaker. When the current is turned on, electrolysis takes place in the dilute acid through which the current has to pass, and the resulting bubbles of hydrogen and oxygen gas block up the pin-holes and interrupt the current. The current ceasing, the bubbles of gas escape and the current recommences. In this way the current was interrupted at the rate of about 10,000 times a minute.

The Cooper Hewitt lamp was operated by the street current reduced by a rheostat to five amperes with 110 volts. The lamp was twenty-four inches long and one inch in diameter. The apparatus was adjustable to any height, and so arranged that a reflector shielded the patient's face and eyes. The light was applied for 15 minutes in front and for the same time in back of the patient's chest at a distance of about 5 or 6 inches.

Electricity in Swedish Iron Mines

IN a paper read recently before the Iron and Steel Institue of Great Britain, Henry Louis described the part taken by electricity in the production of pig iron at the Herraeng Iron Mines, in Sweden.

The ore, as mined, is conveyed from the various mines by aerial wire ropeways to the crushing works, where it is broken and crushed wet; the pulp thus produced runs to the magnetic concentrators, which take out the magnetite; the latter is conveyed by a small aerial ropeway to the briquetting house, where it is mixed with a binder and stamped into briquettes, which pass next through the briquetting furnace in which they are burnt.

They are then hoisted to the top of a pair of charcoal furnaces, where they are smelted for high-class pig iron; the waste gases from the blast furnace fire the briquetting furnaces, and supply gas for the engines which furnish the blast and drive the dynamos of a central electric station, from which power is conveyed to the concentrating works, as well as to the various mines for hoisting, pumping, and the like.

Telegraphy in the Congo States

IN the construction of a 750-mile telegraph and telephone line in the Belgian Congo district, says "Engineering," of London, great difficulties were encountered in crossing several large streams. At Underhill the river was crossed by means of two steel towers, 50 feet high and 2620 feet apart, placed respectively 237 feet and 206 feet above high-water level.

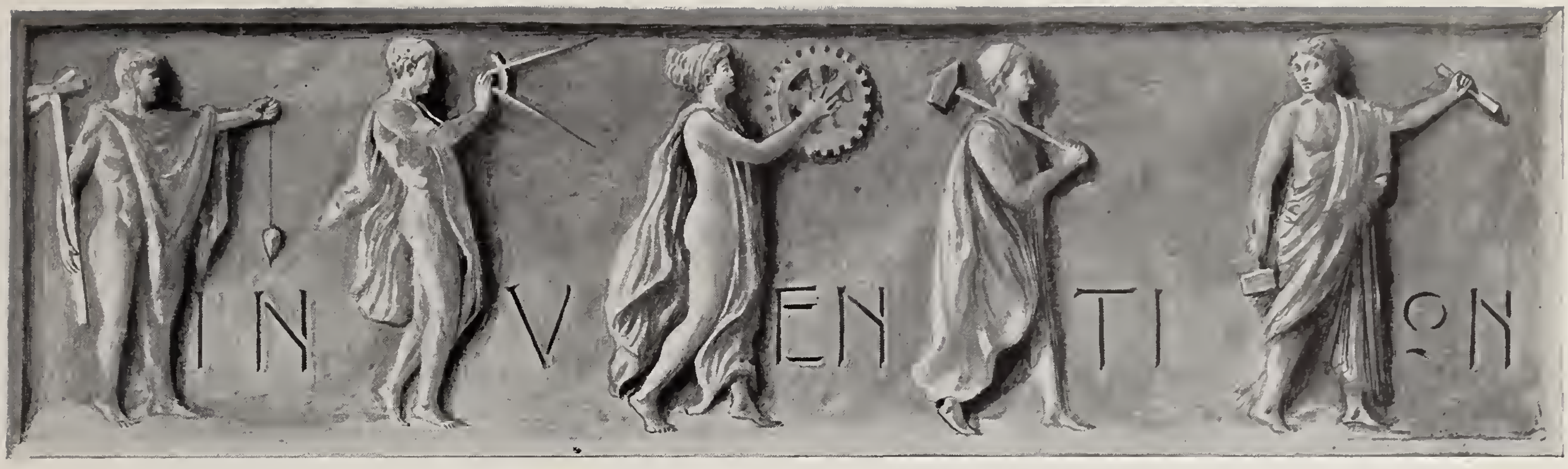
The crossing of the Kasai was probably the most difficult, as it was necessary to keep the stream clear for summer traffic. Advantage was taken of a rocky island in the river, and the crossing was made in two spans, one of 1472 feet and the other of 2198 feet, three supporting towers being used.

Copper Production of the United States

ACCORDING to Walter Harvey in "The Mining Magazine," the production of metallic copper in the United States for 1903 was 698,044,517 pounds of a value of $91,-506,006. In 1902, 44 per cent., or about 289 million pounds, were produced from an area a mile long and one-half mile wide, at Butte, Montana; 26 per cent., or about 156 million pounds, from a strip of country two to six miles long, extending through the center of Keweenaw Peninsula, Michigan; and 18 per cent., or 130 million pounds, from four isolated districts in Arizona.

Of the remaining 12 per cent., the greater amount comes from Bingham, Utah; Keswick, Cal., and Ducktown, Tenn. The gold and silver mines of the country, notably those of Colorado, contribute about one per cent. of the total production, as a by-product in smelting for the precious metals.

The total number of telegrams transmitted in all countries in 1903, is given as 364,848,474.



Electrical and Mechanical Progress

The Box Electric Rock Drill

AN electric rock drill, made by the Denver Engineering Works Company, of Denver, Col., and illustrated on this page, probably represents the latest development in the application of electricity to mining operations. This drill was invented by W. A. Box and is more compact than the earlier forms of electric drills in which the power was obtained from an electric motor through a flexible shaft.

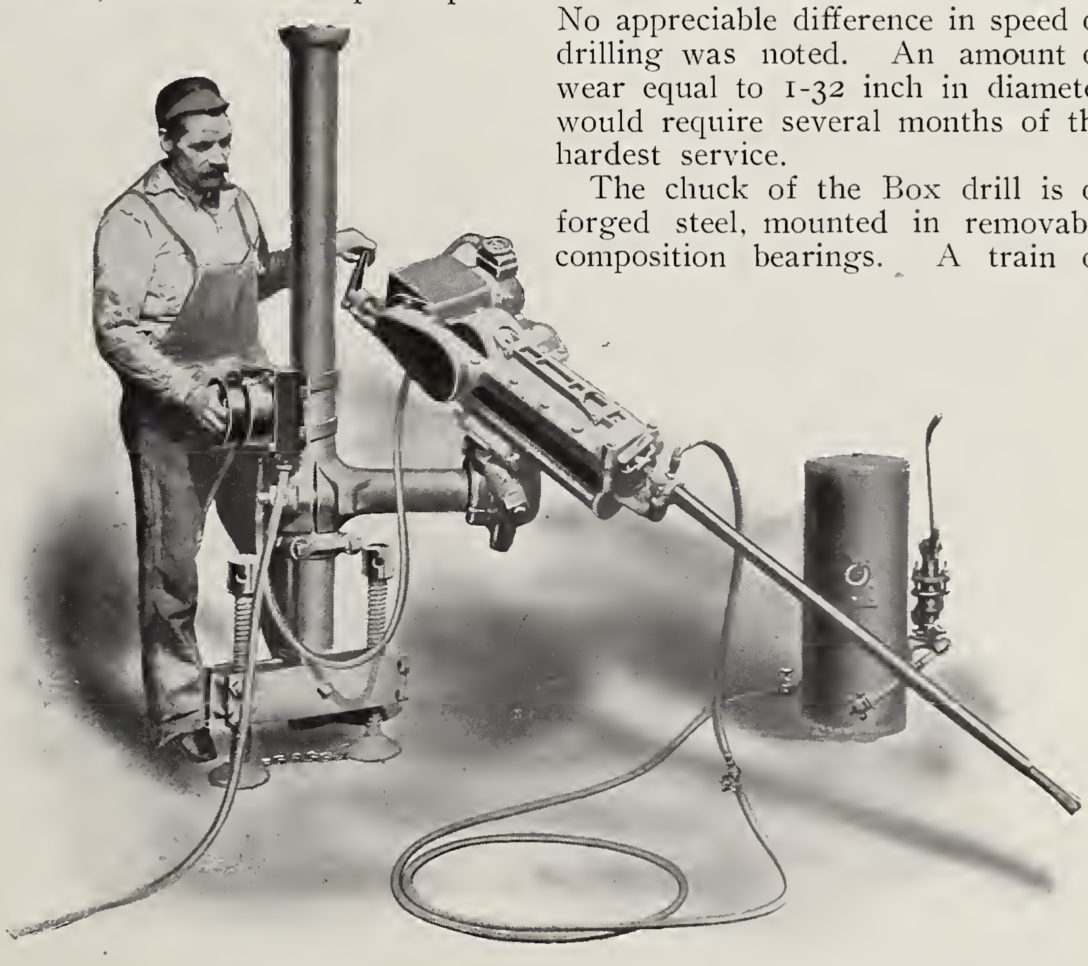
A clear idea of the construction of this drill may be had from the cross-sections on the next page. The electric motor, designed to be waterproof, is shown at the left, mounted on the guides of the shell and coupled to the drill proper by means of machine-cut forged-steel gears. A taper pin, with nut, fastens the motor to the drill, and the removal of this pin allows the motor to be removed. The crank is connected to the cross-head by means of a connecting rod, the cross-head being a cylinder in which is fitted the hammer of the drill. This cylinder of cast iron is machine-finished inside and out, and the forged-steel hammer is machine-finished all over and fitted to the bore of the cylinder.

The hammer resembles the piston and rod of a steam engine, an air space being left between the piston of the hammer and the heads of the cylindrical cross-head. When the drill is in motion, the air on each side of the hammer-piston is alternately compressed and rarefied, giving exactly the effect of a spring between the cylindrical cross-head and hammer, thus furnishing an element which is indestructible.

To compensate for possible leakage and to insure a full supply of air, two ports are cut in the side of the moving cylinder, and are so located that as soon as the piston moves from its central position one port is opened to the atmosphere and a supply of air rushes in; then the other port opens and furnishes an air supply to the other side of the piston. Thus, these two ports serve to equalize the air pressure on both sides of the piston as it passes its central position. Oil grooves are turned in both piston and rod to furnish an oil packing between the piston and the cylinder walls, and also between the rod of the hammer and the cylinder head.

In order to ascertain the effect of wear, one of the pistons was turned down 1-32 inch smaller in diameter, and the drill was used on hard rock. No appreciable difference in speed of drilling was noted. An amount of wear equal to 1-32 inch in diameter would require several months of the hardest service.

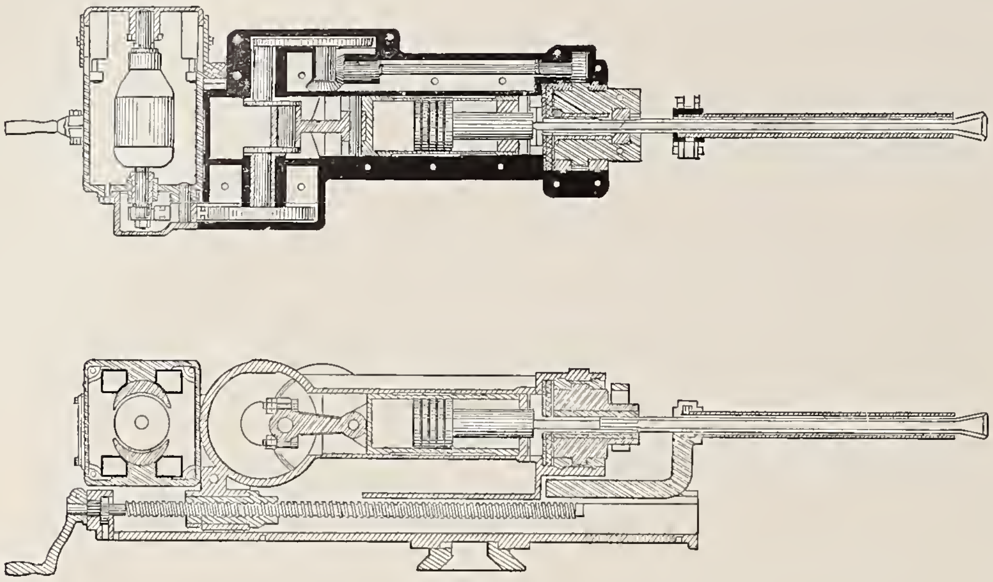
The chuck of the Box drill is of forged steel, mounted in removable composition bearings. A train of gears, driven from the main crank-shaft, gives a continuous rotation to the chuck by means of a gear cut on the outside surface of the chuck. In the chuck is mounted an automatic key engaging two flattened surfaces forged in the drill bit, thus allowing an



THE BOX ELECTRIC ROCK DRILL, MOUNTED ON A TUNNEL COLUMN WITH CONTROLLER AND WATER-TUBE AND CONNECTIONS FOR COOLING THE DRILL AND PREVENTING DUST. BUILT BY THE DENVER ENGINEERING WORKS COMPANY, DENVER, COL.

end play in the drill bit of about 1 inch, but compelling the bit to turn with the chuck.

For removing the crushed rock from the drill-hole, a long steel tube is placed over the drill-bit in order to deliver a stream of water to the cutting-edges of the bit. This tube, of an internal diameter slightly larger than the outside diameter of the drill-bit, has a groove cut on the outside surface for almost the whole of its length, similar to a key-way in a shaft.



CROSS-SECTIONS OF THE BOX ELECTRIC DRILL

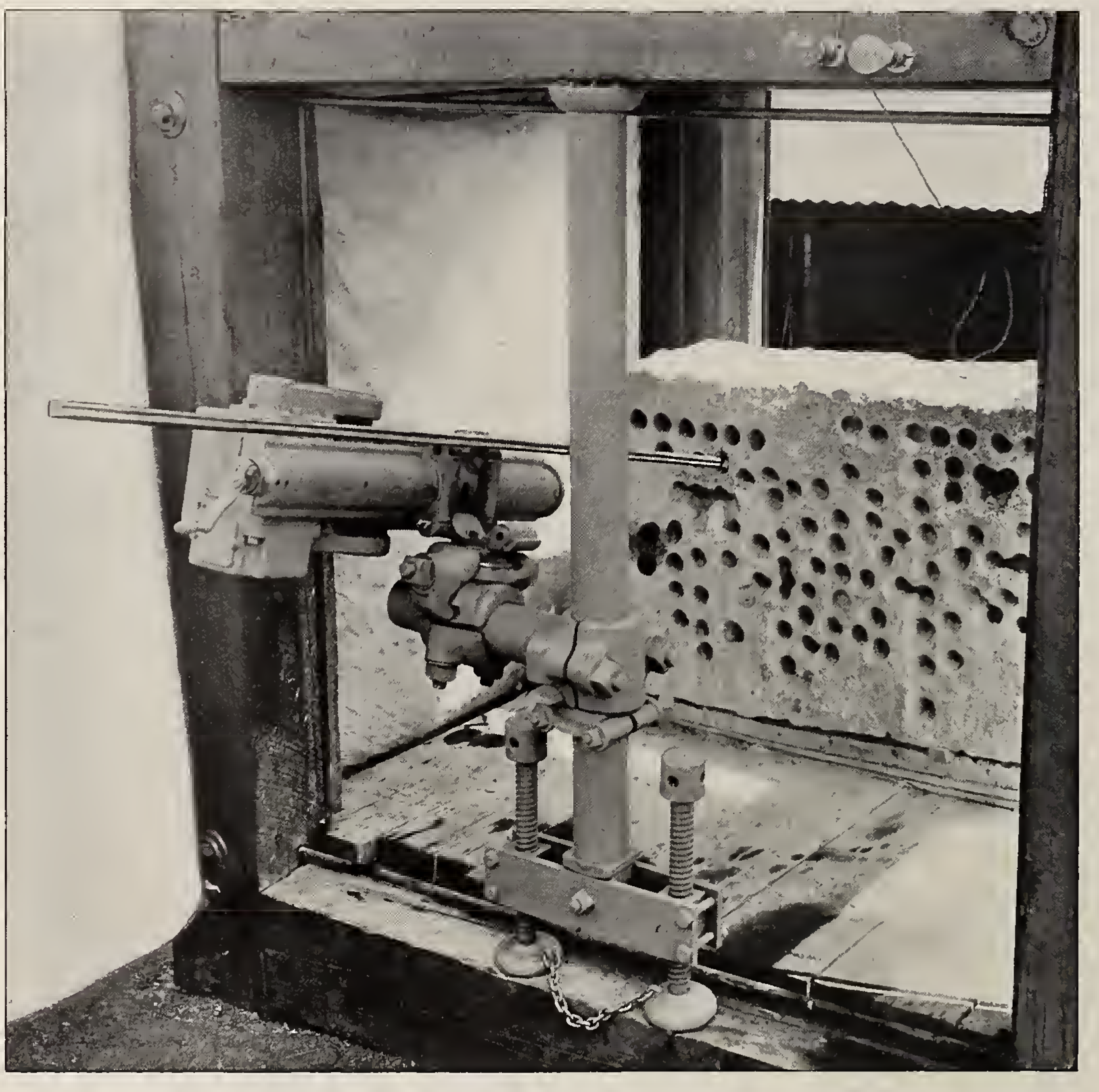
Another steel tube is pressed over the inner tube, thus leaving a hole through the shell of the finished water-tube. One end of this tube is fastened to a bracket bolted to the chuck end of the drill. In this bracket is a water-duct, connected by rubber hose and suitable fittings to a portable tank holding a supply of compressed air and water.

When the water-valve is open, a stream of water is delivered with a concentrated washing-action to the point of the drill-bit, and the small rock particles cut out by the drill are washed back from the bottom of the hole on the outside of the tube to the face of the workings. In this manner the making of dust is prevented and the temper of the drill is preserved. The tube also acts as a guide for the drill steel.

Another important improvement consists of a hinge between the guide-shell and the cone of the clamp, which enables the whole drill to be tipped to one side or the other, thereby enabling long drill steels to be quickly inserted or removed from the drill or the hole without disturbing or changing the set-up of the drill. When the drill is tilted back into place, it is again in proper alignment with the hole.

The illustration on this page shows this feature clearly. The guide-shell, drill and motor are mounted on a tunnel-column shaft-bar, with clamp and arm, or on a tripod.

The electric current is conducted from the main transmission wires to the controller through heavy, rubber-covered mains; the controller is of special design, and includes the necessary resistance for five speeds with proper fuse-blocks, all contained in a compact, aluminium, waterproof case. Connection is made with the drill motor by a short, heavy, rubber-insulated cable. The electric motor was designed by the General Electric Company, of Schenectady, N. Y., expressly for this drill and service. While every means are employed to reduce the weight and size, all precaution is taken for careful insulation and substantial construction. The motor has a waterproof case, and aluminium caps are used on the pinion and the commutator end. Suitable hand-hole plates are provided for inspection and care of the carbon brushes. The motors are wound for either 110 or 220 volts, direct current.

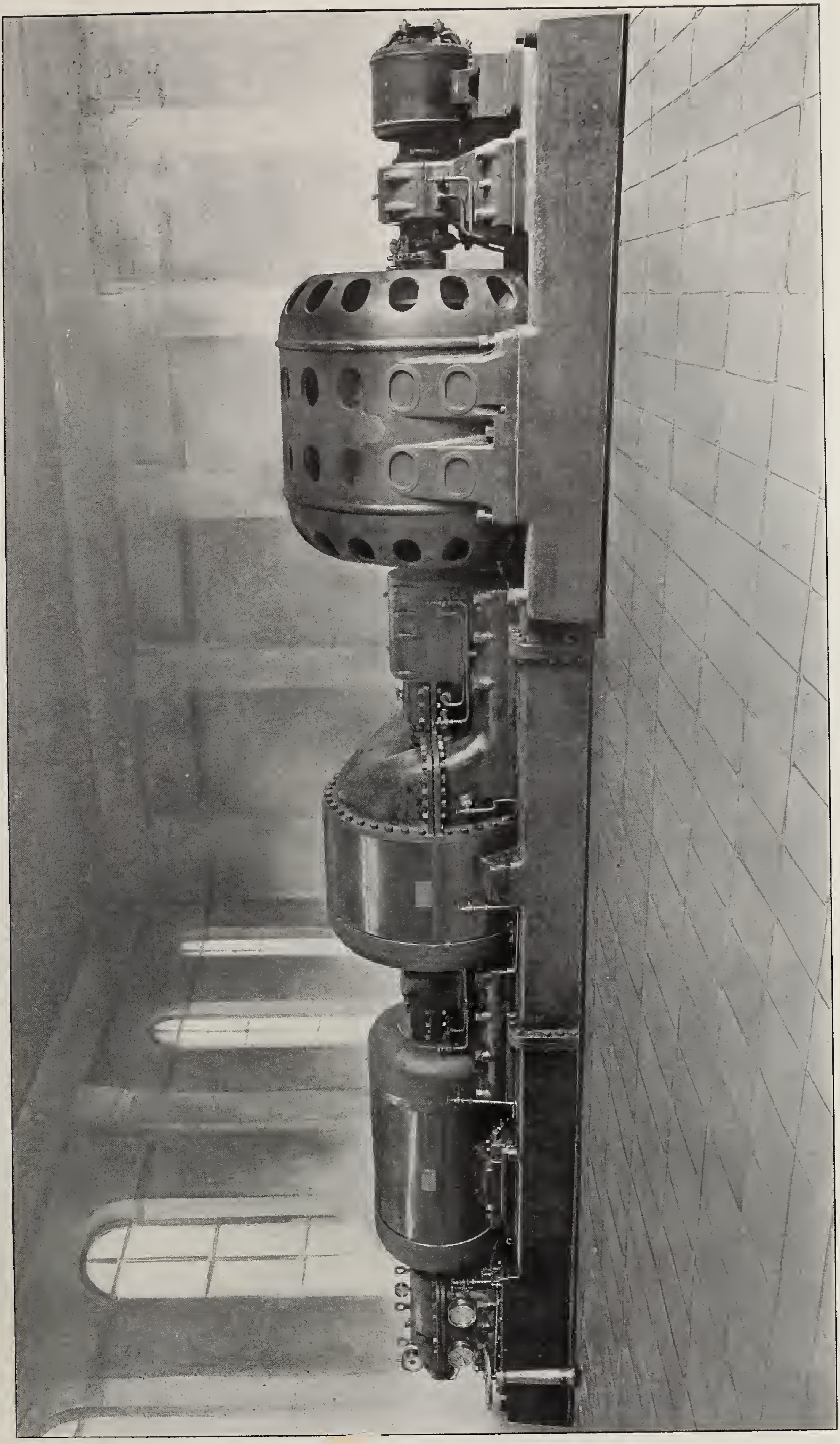


THE HINGED GUIDE SHELL OF THE BOX ELECTRIC DRILL, SHOWING HOW GUIDE SHELL, DRILL AND MOTOR MAY BE TIPPED OVER TO ALLOW REMOVAL OR INSERTION OF DRILL STEELS, WITHOUT CHANGING THE SET-UP OF THE DRILL.

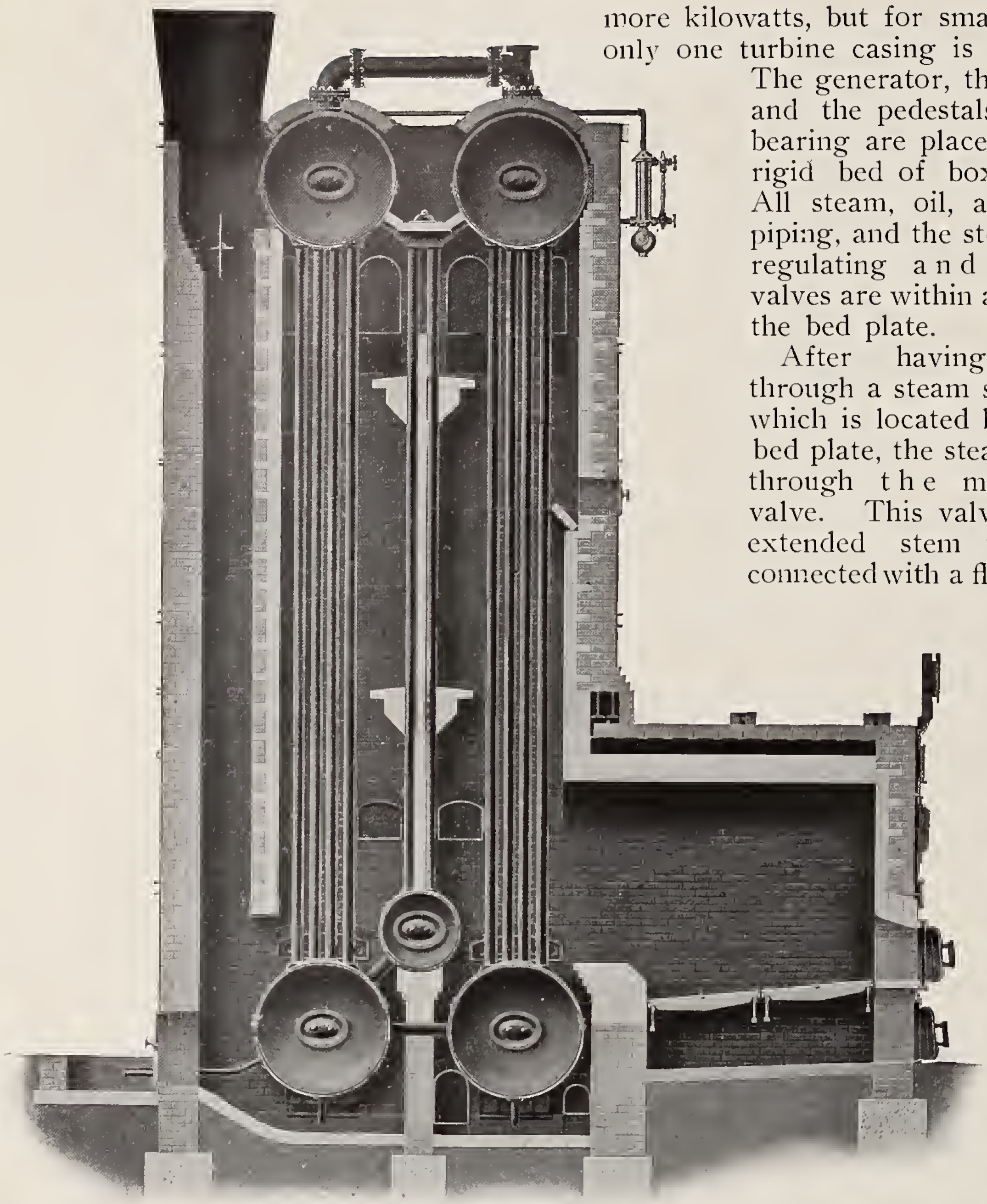
The Hamilton-Holzwarth Steam Turbine

AN interesting example of the progress made in the development of the steam turbine is furnished by the exhibit of the Hooven, Owens, Rentschler Company, of Hamilton, Ohio, in Machinery Hall at the St. Louis Exposition. It consists of a Hamilton-Holzwarth steam turbine, direct connected to a 1000-K. W. generator built by the Bullock Electric Manufacturing Company, of Cincinnati, Ohio. The turbine is designed to operate with 185 pounds pressure, at 1500 revolutions per minute, and with 28 inches of vacuum.

As will be seen from the illustration on the opposite page, the turbine



THE HAMILTON-HOLZWARTH STEAM TURBINE, BUILT BY THE HOOVEN, OWENS, RENTSCHLER CO., HAMILTON, OHIO, AND SHOWN AT THE ST. LOUIS EXPOSITION, DIRECT-CONNECTED TO A 1000-K. W. GENERATOR, BUILT BY THE BULLOCK ELECTRIC MANUFACTURING CO., CINCINNATI, OHIO



A SECTIONAL VIEW OF THE WATER-TUBE BOILER MADE BY THE RUST BOILER CO., PITTSBURG, PA.

consists of two parts, one for high and one for low pressure working. This arrangement holds for units of 750 or more kilowatts, but for smaller units only one turbine casing is provided.

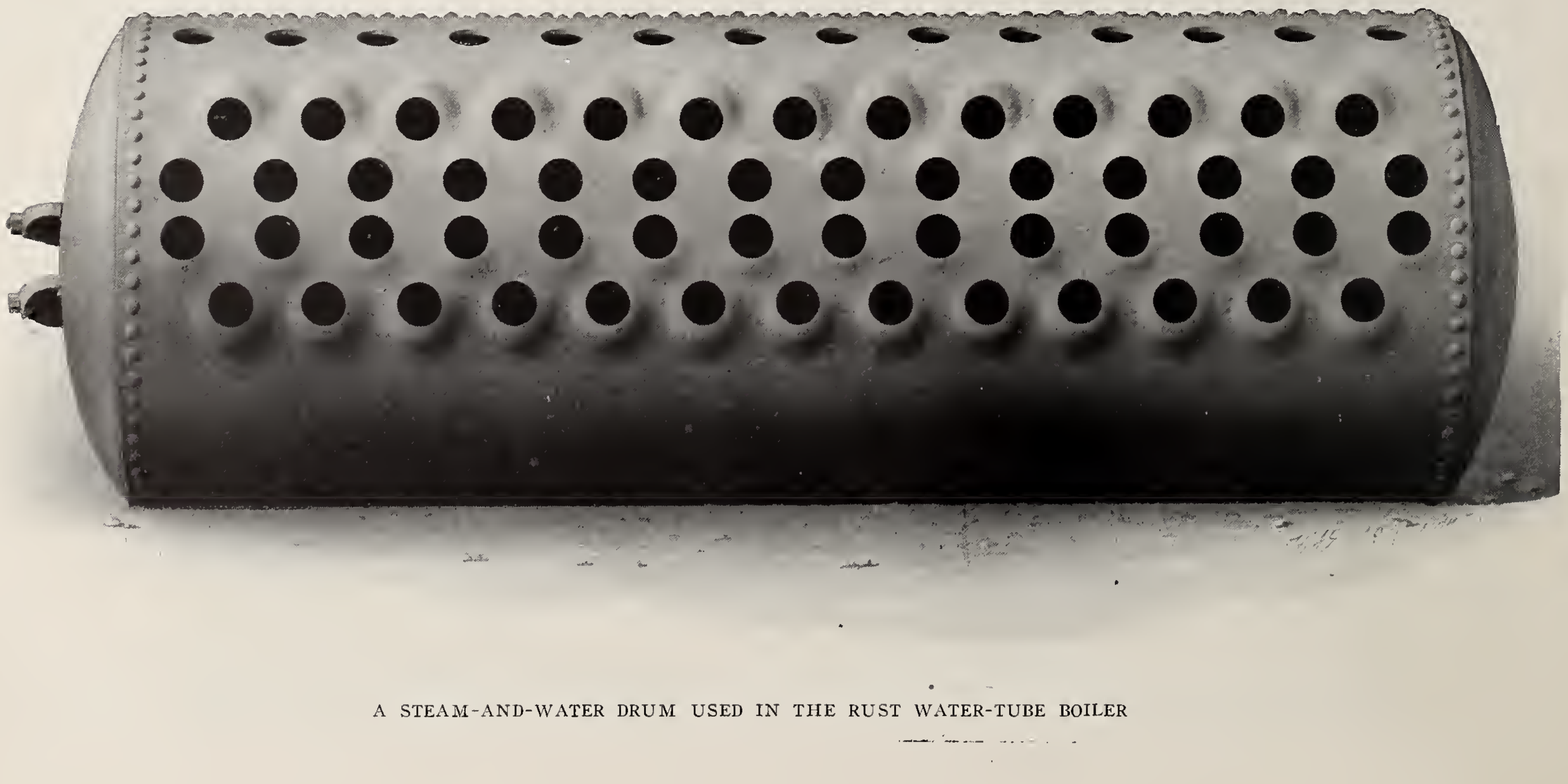
The generator, the casings and the pedestals for the bearing are placed upon a rigid bed of box pattern. All steam, oil, and water piping, and the steam inlet, regulating and by-pass valves are within and below the bed plate.

After having passed through a steam separator, which is located below the bed plate, the steam passes through the main inlet valve. This valve has an extended stem which is connected with a floor stand and handwheel located on the floor close to the high pressure end of the turbine. The steam then passes through the regulating valve and thence through a curved pipe to the head of the high pressure turbine. After the steam has passed through the series of fixed and moving vanes in the high-pressure turbine, it then passes through receiver pipes to the front head of the low pressure casing, or if there is only one casing, immediately to the condenser. This condenser, of either jet or surface type, is placed as near as possible to the exhaust opening. In the low-pressure casing, the steam is distributed in the same manner as in the high-pressure turbine. The low-pressure front head, however, has an additional nozzle through which live steam enters the low-pressure casing for use in case of overload. The design is such that this steam, the supply of which is controlled by the governor, exerts no back pressure to the steam from the high-pressure turbine. On the contrary it works like an injector, sucking the low-pressure steam through the first stationary vanes of the low-pressure turbine.

The stationary discs are placed in grooves in the turbine casings, which are split horizontally. The vanes in the discs are of drop-forged steel, milled and placed in a groove on the periphery of the discs. The vanes are fastened to the discs by rivets, after which the discs and vanes are ground on the outside edges. A steel ring is then shrunk on over the vanes.

The running wheels, or moving parts of the turbine are made of steel discs riveted to cast steel hubs, and form a ring space into which the vanes are riveted. A steel ring is also shrunk over these vanes as on the stationary discs.

The bearings for the turbine shaft have much less weight to support than



A STEAM-AND-WATER DRUM USED IN THE RUST WATER-TUBE BOILER

those of the generator shaft, and therefore can be made short with straight cylindrical shells, while it is necessary that the bearings of the generator have ball-shaped shells to insure the alignment of the shaft. In both kinds of bushings or shells the top and bottom halves are screwed together. The pedestals and the caps are designed in such a manner that the oil inlet and outlet are placed close together on the side of the pedestal, so that no piping has to be deranged to take out the bushings. The oil flows to the bottom bushing under a slight pressure and then flows with the rotating shaft and is taken off in the cap. From here it flows back to the oil outlet in the pedestal.

A flexible coupling between the high and the low-pressure shafts and between the low-pressure and generator shafts allows each shaft to be adjusted independently of the others. The high and the low-pressure shafts are held at the exhaust end of each casing by the bearing pedestals, and as the casings are not fastened to the bed plate, they and the shafts are free to expand in a direction opposite to that in which the steam flows.

The governor is of a spring and weight type especially designed for turbine governing. To reduce the friction in the governor and the regulating mechanism to a minimum thrust ball bearings and frictionless roller bearings are used. The governor is directly driven by the turbine shaft and revolves with the same angular velocity.

All the bearings of the turbine-generator are fed with oil from a pump driven by worm gearing from the turbine shaft. Part of the bed plate is used as an oil tank, the oil flowing back through a strainer after being forced through the bearings.

The Rust Water Tube Boiler

THE water-tube boiler built by the Rust Boiler Company, of Pittsburg, Pa., and illustrated on the opposite page, presents some novel features of construction. Prominent among these is the pressed tube sheet forming part of each of the five drums.

This tube sheet is formed by heating a flat plate and pressing it in a hydraulic press fitted with dies. As will be seen in the illustration of the drum opposite, there remain between the pressed-up portions cylindrical belts of the original surface. This construction provides a drum in which bent tubes or stayed surfaces are not necessary, and which is as strong and reliable as those in which it is necessary for the tubes to enter radially.

The boiler proper consists of two steam-and-water drums, two mud drums and an auxiliary drum, each steam-and-water drum being placed directly above a mud drum and connected with it by a bank of straight vertical tubes, the two mud drums being connected by a row of tubes. The auxiliary drum is placed above and between the mud drums, and is connected to one of them by a row of short tubes and to a series of small headers by a bank of straight vertical tubes. These headers are placed between the steam-and-water drums and connect with them by short, straight tubes. Each drum is fitted with the patent pressed tube sheet, already described.

The holes for the tubes forming the main banks are so spaced that the tubes are staggered. The spacing of these tubes is such as to leave room enough between the tubes of the outside rows to remove the tubes of the inner rows. The tubes are brought outside through doors in the side of the setting.

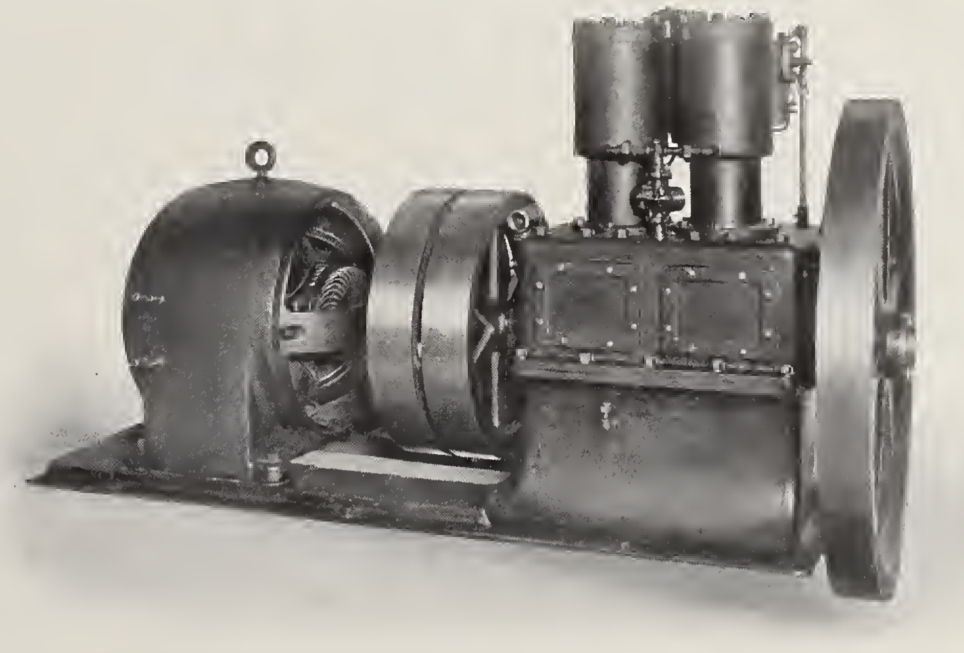
A baffle wall is built of tiles supported between the rows of the central bank of tubes. Horizontal baffles also project from the central baffle wall and serve to deflect the hot gases toward and between the tubes in the main banks.

The boilers are made to be set singly or in batteries of two. Each drum is provided with a manhole in one end to allow access to the interior of the drum, and in the top of each header is a hand hole through which to reach the tubes of the central bank.

The steam spaces of the steam-and-water drums are connected by cross pipes of liberal dimensions. On top of each is an outlet, on which is placed a nickel-seated safety valve. The steam outlet is placed on top of and at the center of the rear steam-and-water drum.

The boiler is supported by four large cast iron saddles on masonry foundations, one saddle being placed under each end of each mud drum, the saddles under one of the drums being placed on rollers so as to allow any slight movement due to expansion.

The setting of the boiler may be readily adapted to an underground flue connection without the use of any pipe or plate work. The furnace may also be adjusted to a grate area suitable for any fuel, or for any style of grate-bar or stoker.



A GAS-ENGINE DYNAMO OUTFIT FOR PRIVATE USE. THE ENGINE WAS BUILT BY THE NATIONAL ENGINEERING COMPANY, OF BRADFORD, PA., AND THE DYNAMO BY THE IDEAL ELECTRIC & MANUFACTURING CO., OF MANSFIELD, OHIO

A Gas-Engine Dynamo

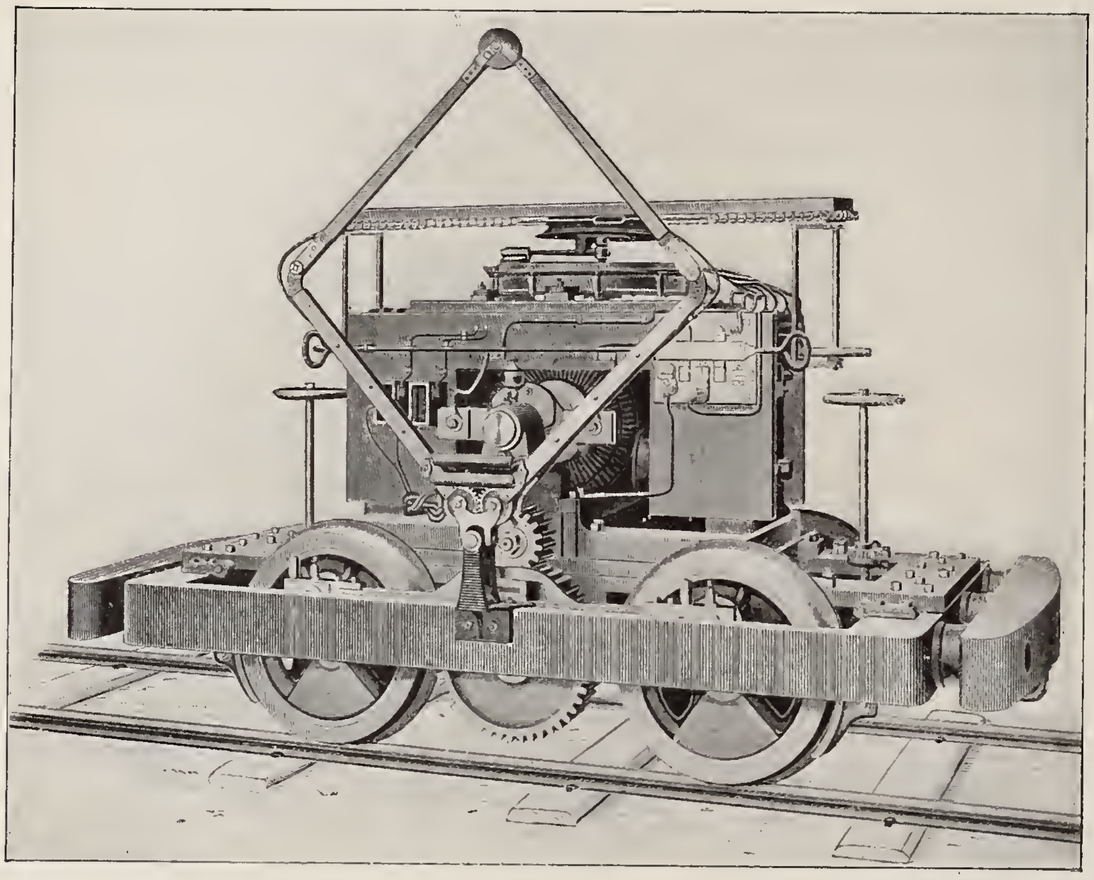
THE generating unit illustrated on this page consists of a 10-H. P. gas engine, made by the National Engineering Company, of Bradford, Pa., direct connected to a 45-ampere multipolar, slow-speed generator, made by the Ideal Electric & Manufacturing Company, of Mansfield, Ohio. This unit was designed for private use, the engine being adapted for working with natural or manufactured gas or gasoline.

Close regulation being a prime requisite for lighting, the engine has been designed to regulate within 2 per cent., and, on a steady load, within less than one half of 1 per cent. It is of the two-cylinder, four-cycle type, the cranks being set so as to give an impulse every revolution. The cranks are counterbalanced.

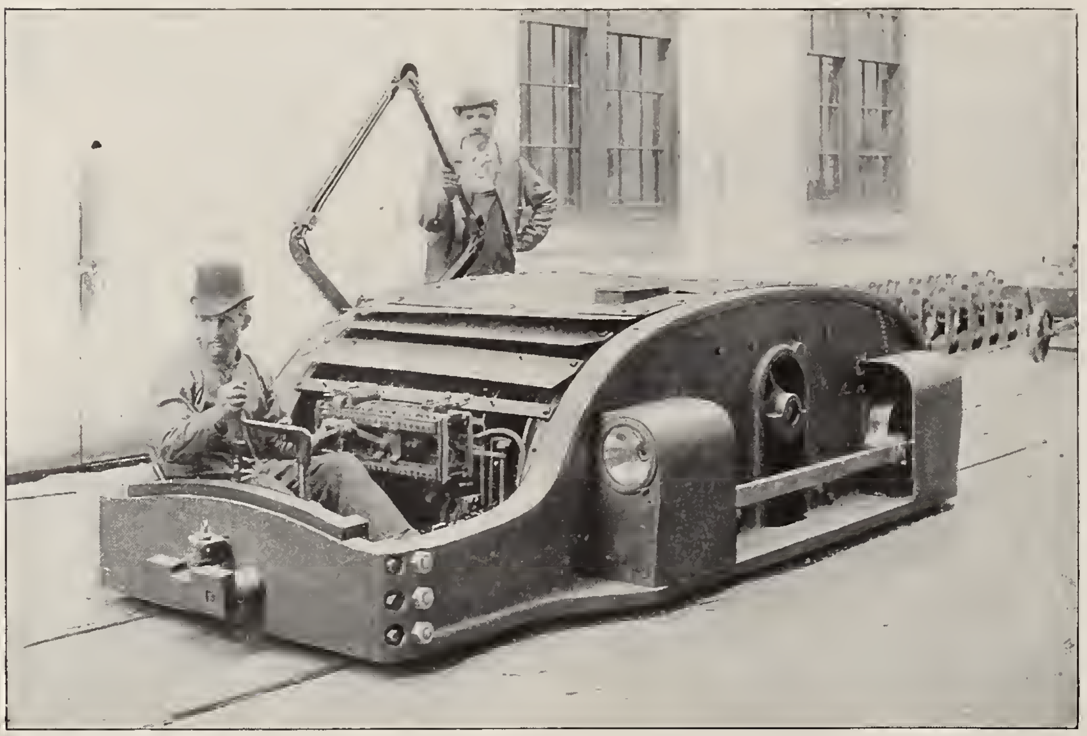
The base of the engine can be divided at the shaft line, and by removing eight bolts the entire top can be raised without removing the cylinder heads, valves, igniters or fly wheels. This gives free access to the bearings when it becomes necessary to replace them. There are three bearings, all of which are adjustable. The cylinder heads, valves or igniters can each be removed separately without disturbing any other part of the engine.

The mixing chamber valves and igniters are all in the same casting and free access to any of them is had by removing a cap. The valve seats are separate from the valve-chest casting and can easily be replaced in case of wear. The igniters are of the "make and break" type, and are so located that the incoming charge tends to cool them, and the exhaust to keep them clean.

The cylinders are made of a special grade of semi-steel. The pistons are long and are provided with improved oil rings. The engine is self-oiling throughout, and no packing is used as the joints are ground in. All the parts are made extra heavy.



ELECTRIC MINE LOCOMOTIVE INSTALLED AT THE ERIE COLLIERY, NEAR SCRANTON, PA., IN 1889, BY THE THOMSON-HOUSTON CO., AND STILL AT WORK



THE THOMSON-HOUSTON "TERRAPIN BACK" ELECTRIC MINE LOCOMOTIVE, USED AT FOREST CITY, PA., IN 1891. THE THIRD IN AMERICA

The magnet frame of the generator is cast round in one piece and is counterbored at each end for mounting to the pedestal brackets. The magnet poles are of forged steel of circular cross section, and are cast welded into the magnet frame. The blocks are machined in such a manner as to insure a cast welded joint and to absolutely prevent the blocks from becoming loose after the frame has been cast. They are also turned down for the reception of cast iron shoes. These shoes protect and support the field winding. The brackets are provided with large oil reservoirs with drain cocks and suitable openings for inspection of the bearings and oil rings. These openings are provided with iron covers.

In the enclosed type of generator cover plates are fitted to the openings in the brackets to prevent the admission of dust. These covers are provided with handles and may be readily taken off for inspection of the motor, or entirely abandoned if desired. For the semi-enclosed type, the cover plates are perforated.

Electric Mine Locomotives

ACCORDING to Mr. W. B. Clark, of the General Electric Company, Schenectady, N. Y., the "Pennsylvania Report of the Bureau of Mines" gives the following figures:—

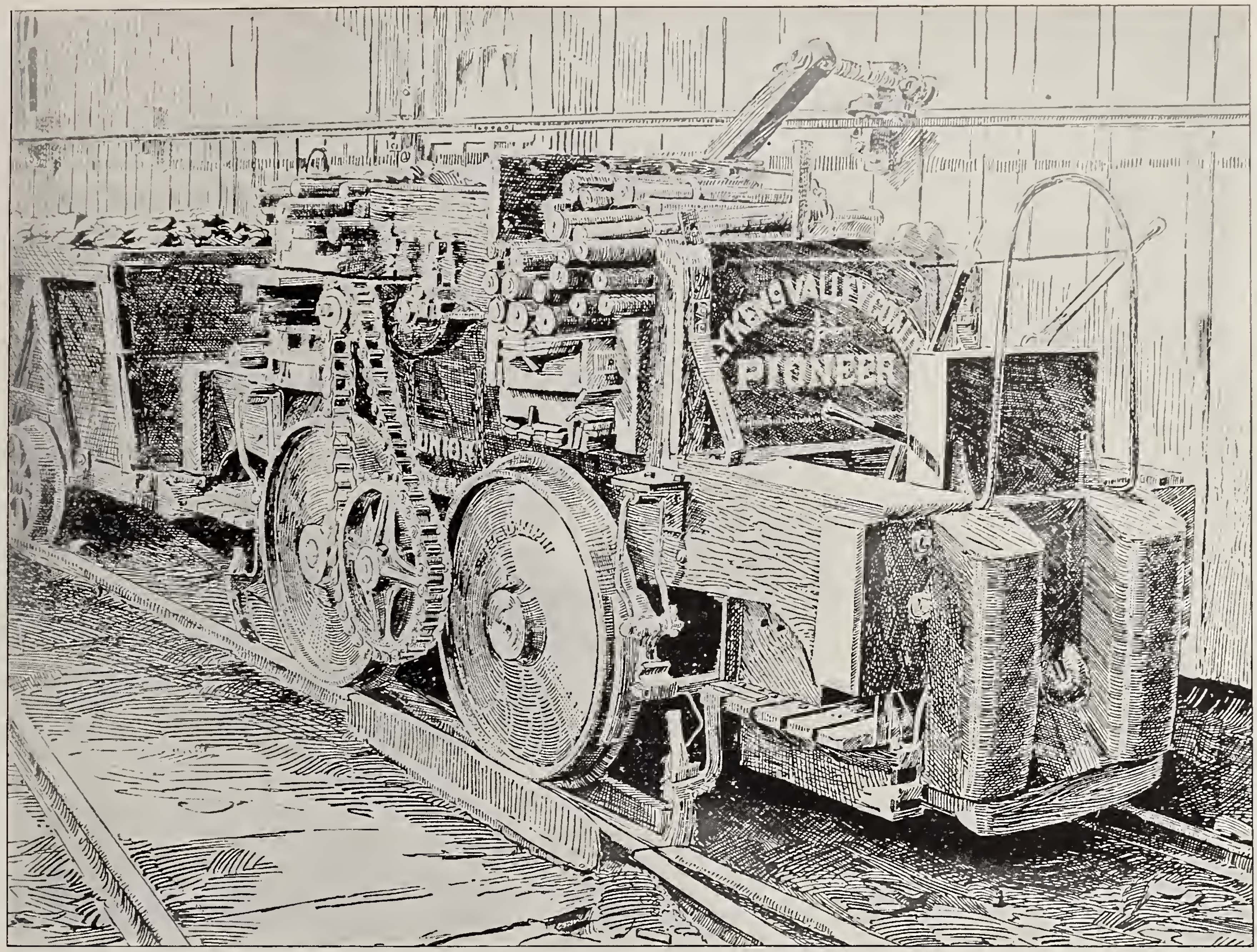
MINE-LOCOMOTIVES IN THE BITUMINOUS DISTRICTS

	Steam	Compressed Air	Electric
1901	134	23	231
1902	130	16	326

MINE-LOCOMOTIVES IN THE ANTHRACITE DISTRICTS

	Steam	Compressed Air	Electric
1901	362	51	40
1902	373	55	53

In the bituminous districts during 1902 the number of steam mine-locomotives decreased 3 per cent., and that of compressed-air locomotives 44 per cent., while the number of electric mine-locomotives increased 40 per cent. In the anthracite districts the report shows an increase in the number of steam and compressed-air mine-locomotives of 3 per cent. and 8 per cent., respectively, while the number of electric mine-locomotives increased 32 per cent. In the spring of 1904 there were in the anthracite districts of Pennsylvania 113 electric mine-locomotives, of which 36 are equipped with the cable-reel, and are employed for "gathering" coal cars from the room-faces. At one time one of these 6.5-ton electric gathering-locomotives hauled cars from the face of a "dripping" room, where the grade was so steep that four mules working tandem were required to haul out one loaded car.



THE FIRST ELECTRIC MINE LOCOMOTIVE BUILT IN THE UNITED STATES. INSTALLED IN 1887 AT THE LYKENS VALLEY COAL MINE, PA.

The first electric mine-locomotive built in the United States, and illustrated above on this page, was put in service in 1887, at the Lykens Valley colliery of the Pennsylvania Railroad Company. A year later this machine was remodeled, and it is still in every-day service, its work during 1901 amounting to 531,584 ton-miles. The first electric mine-locomotive built by the Thomson-Houston Electric Company was constructed in 1889 for the Erie colliery of the Hillside Coal & Iron Company, and this machine, shown on this page, is also still in every-day service.

The figures quoted above show that at the end of 1902 there were 376 electric mine-locomotives in the coal mines of Pennsylvania alone. In round numbers, 450 electric mine-locomotives were built in the United States during 1902. The production during 1903 was considerably larger.

Leeds, England, has instituted an evening class for the technical instruction of its municipal tramway employees.

A MODERN TYPE OF ELECTRIC MINE LOCOMOTIVE WITH CABLE REEL, PERMITTING ITS USE AS A GATHERING LOCOMOTIVE. MADE BY THE GENERAL ELECTRIC CO., SCHENECTADY, N. Y.

The Telautograph in Railroad Service

According to "The Railroad Gazette," Gray's telautograph, a telegraph instrument which records a message at the receiving end in the handwriting of the sender, is now in use at the Union Station, at St. Louis, for announcing at various points in the station the prospective arrival of trains.

The sending operator is in the signal tower at the entrance to the station yard, and he writes his message announcing each train as soon as the train comes within sight; and as all trains run past the tower and are backed in, this gives the men in the station about five minutes advance notice. During the busy hours of the morning and evening the sending operator keeps his line at work almost continuously.

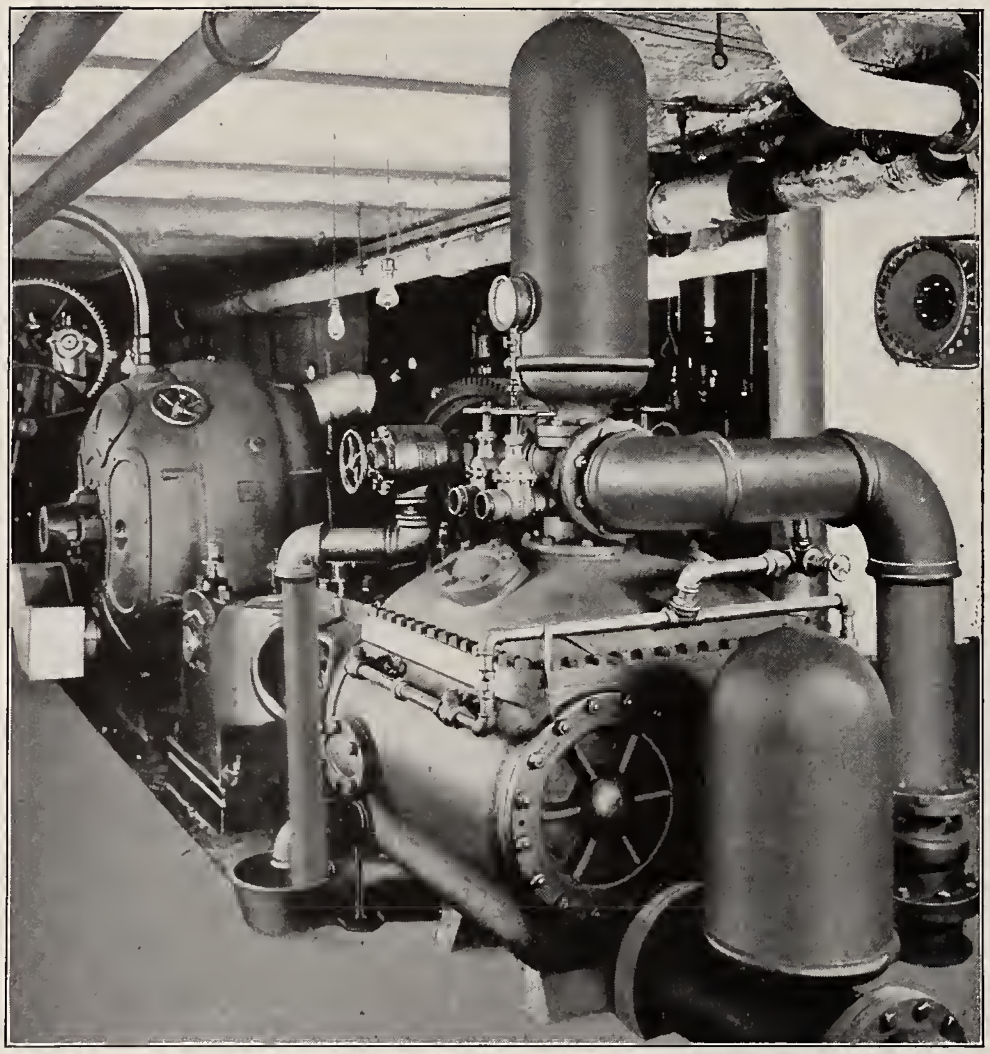
There are receiving instruments in the station master's office, the baggage room, the information bureau and a number of other places at which prompt information concerning incoming trains is desirable. For each train the number of the track on which it will come in is given in the message.

The advantage of this method of communication over the telegraph is in the fact that no operator is necessary at the receiving end; and, as compared with the telephone, there is also the advantage of accuracy, the person at the receiving end not giving any particular attention to the apparatus. With a sending operator who writes a clear, legible hand, the apparatus assures clear and legible bulletins at all the receiving stations.

The sending operator has a receiving apparatus connected to the line in his own office so that he always sees the record of what he is sending. Any intelligent person who can write can send the messages, and the receiving instrument is self-registering, so that there is no delay if the person at that end is absent from his office.

A Motor-Driven Fire Pump

No modern building is complete without some apparatus for use in extinguishing fire. Its utility has been demonstrated in the recent Baltimore and Toronto fires, in which many buildings were saved by the effective use of private apparatus. The illustration on this page, therefore, will be of interest as showing a recent installation of a motor-driven fire pump in Marshall Field's immense department store in Chicago.



A MOTOR-DRIVEN FIRE PUMP INSTALLED BY THE INTERNATIONAL STEAM PUMP CO., NEW YORK, IN THE DEPARTMENT STORE OF MARSHALL FIELD, CHICAGO. THE MOTOR WAS FURNISHED BY THE CHICAGO EDISON CO.

The outfit consists of a Laidlaw-Dunn-Gordon duplex "Underwriter" pump made by the International Steam Pump Company, of New York, and connected by single-reduction gearing to a waterproof electric motor. The pump cylinders are 8 inches in diameter, the stroke being 12 inches. The pump has a theoretical capacity of 700 gallons per minute, at 600 revolutions per minute, against 140 pounds water pressure. The illustration shows the special attachments and the large pressure and vacuum chambers required by the Underwriters' specifications. The pump is thoroughly rust proof in all moving or wearing parts.

The motor was furnished by the Chicago Edison Company, and is shunt wound for 220 revolutions per minute at 230 volts. It is enclosed, all connections being carried through pipes screwed into the frame, so that the device may be flooded without its action being affected. The fields and armature coils are cooled by fans on the armature shaft. The ventilator intake and outlet are visible in the illustration. This combination has been designed to insure reliability and certainty of action under all conditions.

One of the important considerations affecting the selection of a device of this sort is the readiness with which electric power can be obtained and utilized, there being hardly a building where a reliable supply of electric current cannot be cheaply and easily obtained. There is, further, no standby or maintenance expense as with steam apparatus.

Personal

J. C. Barclay, assistant general manager of the Western Union Telegraph Company sailed for England on September 23, on the White Star liner "Arabic," which had also on board a large contingent of the British electrical engineers homeward bound. Mr. Barclay has but recently recovered from a severe accident with his automobile, when, to avoid running down some careless people, he steered into a tree and sustained bad contusions.

Oliver Shiras, manager of one of the branch offices of the British Westinghouse Company in England, has resigned his position and has returned to New York to take up an important new position as electrical superintendent of the parent and subsidiary companies of the International Nickel Company, of New York. Mr. Shiras was graduated from Cornell University in June, 1897, taking the degree

of mechanical and electrical engineer, and afterward, up to the year 1900, acting as assistant to the chief engineer of the New York Telephone Company.

Edward E. Goudey, who recently resigned from the general management of the Goudey-McLean Company, of New York, to take a partnership interest in the engineering firm of B. F. Bell & Co., is one of the incorporators of the Bell Engineering & Construction Company, of 220 Broadway, New York. This is a New York corporation, organized to succeed B. F. Bell & Co. and carry on the business of consulting and contracting engineers. Mr. Goudey, who is well known in electrical circles, is treasurer of the company.

An interesting story is going the rounds regarding the discovery, by Lord Kelvin, of the principle of the well-known mirror or reflecting galvanometer. At the time of his discovery, Lord Kelvin, then Sir William Thomson, was puzzling over the difficulty of perfecting the ordinary telegraphic apparatus, as used on overhead land lines, in order to make it suitable for recording the varying currents passing along submarine cables. The ordinary needle galvanometers, for well-known reasons, proved unsuitable. One day, the experimenter's eye-glass fell off and swung in front of the magnet, reflecting its movements, and instantly the idea of the mirror suggested itself. Thus, a monocle may be credited with a direct effect on modern science.

H. M. Davis, manager of the advertising department of the Sprague Electric Company, of New York, has gone West on a pleasure trip of two or three weeks. He is accompanied by his wife and daughter and will take in part of the St. Louis Exposition and make a visit to his former home in Kansas.

Carl Wiler, of the Western Electric Company, Chicago, sailed on September 20th for Königsberg, Germany, Mr. Wiler expects to return about October 20th and will bring with him a wife from his native country.

Mark Bary and Geo. E. Schreiber have formed a partnership under the firm name of Bary & Schreiber, mechanical and electrical engineers, with offices in the Mermod & Jaccard Building, St. Louis. They will act as consulting and supervising engineers in the complete equipment of lighting and railway systems and in the mechanical and electrical equipment of buildings for manufacturing, offices, hotels or other purposes. Special attention will be paid to tests, reports, machine design, etc. Mr. Schreiber was until recently connected with Ford, Bacon & Davis, engineers, of New York and Kansas City. Mr. Bary was for a number of years with H. H. Humphrey, the well-known consulting engineer, of St. Louis.

W. R. Whitney, professor of chemistry at the Massachusetts Institute of Technology, has resigned to take charge of the research laboratory of the General Electric Company at Schenectady.

Mr. Ralph D. Mershon has lately been in Niagara Falls, N. Y., conducting a series of interesting experiments on the high voltage transmission of power, with a view of utilizing his conclusions in connection with the transmission line between Shawinigan Falls and Montreal.

Charles F. Scott, past president of the American Institute of Electrical Engineers, and formerly chief electrician of the Westinghouse Electric & Manufacturing Company, bears now the title of consulting engineer for the company.

W. E. Gilmore, vice-president of the Edison Manufacturing Company, Orange, N. J., and New York City, returned last week from an extended trip throughout the West. Mr. Gilmore reports that there are good prospects for a busy season through the entire country.

C. O. Baker, president of Baker & Company, Inc., platinum refiners and manufacturers, of Newark, N. J., and New York City, recently returned from an extended European trip. He reports that the prices of crude platinum have been very materially affected by the drafting of the laborers from the Ural mines, owing to the Russo-Japanese war, and, notwithstanding recent advances, a further rise in prices seems almost assured.

Philip W. Moen, formerly general manager and vice-president of the Washburn & Moen Manufacturing Company, of Worcester, Mass., and later vice-president, director and the Eastern manager of the American Steel & Wire Company, died very suddenly at his summer residence, Shrewsbury, Mass., on September 12, aged forty-seven years. Mr. Moen was graduated from Yale University in 1878, and then went to Sweden to study the steel-making industry. Upon the death of his father in 1891, Mr. Moen succeeded to his interests in the firm of Washburn & Moen, becoming vice-president and general manager. The last two years of his life were spent away from business, his time being devoted to the management of his property.

Dr. P. Heroult of La Praz, France, the inventor of the electric process of aluminium smelting, has been in Ottawa, Canada, recently. It is understood that he has completed arrangements with local capitalists for the development of large iron deposits near Ottawa. Electric smelting works will be established and will be operated by electricity developed from Chats Falls.

Frederick G. Sykes, for the last two years electrical engineer of the Schenectady Railway Company, of Schenectady, N. Y., has resigned from the company to become general superintendent of the Portland General Electric Company, of Portland, Ore. Previous to his connection with the Schenectady Company, Mr. Sykes was employed by the General Electric Company in installing the Sidney Tramway system in Sidney, Australia. His connection with the General Electric Company followed his serving as operating superintendent of the Brooklyn Edison Company.

Charles A. Lieb, well known in electrical circles, has been appointed mechanical director of the Manhattan Transit Company, of New York. Mr. Lieb is an enthusiastic advocate of the solution of the New York City traffic problem by means of auto cars, a work which the Manhattan Transit Company is to take up under his direction without delay.

J. DeSmet Maguire has resigned his position as special representative of the National Electric Company, of Milwaukee, to assume the presidency of the American Electric & Controller Company, with headquarters at New York.

Recent Allis-Chalmers Personal News

Charles S. Buell, mechanical engineer, who until recently represented the Westinghouse Machine Company in Chicago, has entered the employ of the Allis-Chalmers Company as salesman and engineer in their power department.

John F. Burke, for a number of years with the Westinghouse Electric & Manufacturing Company, in Omaha, Neb., has joined the selling force of the Allis-Chalmers Company, with headquarters in Omaha, Neb., and will engage in the sale of Corliss engines, electrical apparatus and crushing and cement machinery for the latter concern.

Wilbur M. Ruth, an engineer of

wide experience in both steam and electrical work, and until recently assistant to the president of the Mesta Machine Company, Pittsburg, Pa., and previously employed on the engineering staff of the E. P. Allis Company, has accepted a position as salesman and engineer for the Allis-Chalmers Company at their Pittsburg office.

M. C. Miller, one of the leading men in the alternating-current department of the Westinghouse Electric & Manufacturing Company, Pittsburg, Pa., has resigned his position with that company to accept a similar position with the Allis-Chalmers Company in their electrical department.

Charles F. Adae, for several years in the employ of the Westinghouse Electric & Manufacturing Company, Pittsburg, Pa., and lately manager of the Pittsburg office of the C. Lee Cook Company, has been appointed to the selling force of the Allis-Chalmers Company, at their New York office.

S. H. Sharpsteen, for a number of years with the General Electric Company as salesman in their New York office, has accepted a similar position with the Allis-Chalmers Company in their New York office.

G. Fred Collins, who has a very extensive acquaintance throughout the East among officials and engineers of large railroad and steel companies, has recently entered the employ of the Allis-Chalmers Company as special representative at their New York office.

W. M. S. Miller, who was in the employ of the Westinghouse Electric & Manufacturing Company in the manufacturing, production and detail correspondence departments, and until lately in the detail and supply department, covering in all a period of about fourteen years, has joined the staff of the Allis-Chalmers Company, with headquarters in Chicago.

R. L. Richardson, for a number of years in the Pittsburg sales office of the Westinghouse Electric & Manufacturing Company, has become a member of the Pittsburg selling force of the Allis-Chalmers Company.

John V. Redfield, after some years in the works and in the Chicago sales office of the Westinghouse Electric & Manufacturing Company, has been appointed to the sales staff of the Allis-Chalmers-Bullock interests at their Chicago office.

James Ashworth, until recently engineer of the city of Chicago, in the Department of Water & Supply, has entered the employ of the Allis- Chalmers Company as salesman in their pumping engine department.

Otto Clyde Ross, for several years employed with the Westinghouse Machine Company as engineer and salesman, and lately in the employ of the Hartford Lead, Zinc, Mining & Smelting Company as engineer, has accepted an appointment with the Allis-Chalmers Company as engineer and salesman.

Trade News

The Electric Controller & Supply Company, of Cleveland, announce the opening of a Southern branch office at 509 and 510 Woodward Building, Birmingham, Ala. This company is now represented in the following cities: New York, Philadelphia, Pa.; Pittsburg, Pa.; Cleveland, Ohio; Birmingham, Ala.; Denver, Col.; San Francisco, Cal., and London, England.

H. M. Byllesby & Company have been appointed engineers and consulting managers of the Oshkosh Gas Light Company, of Oshkosh, Wis. This company has purchased the plant of the Oshkosh Electric Light & Power Company formerly owned by the United Electric Securities Company, of Boston, Mass.

The Hooven, Owens, Rentschler Company, of Hamilton, Ohio, have just secured several orders for Hamilton Corliss engines. These include a 1400-horse-power, cross-compound, condensing engine, to be direct connected to a General Electric generator, purchased by the Hoosac Valley Street Railway Company, of Pittsfield, Mass.; a 1000-horse-power, cross-compound, condensing unit to to be direct connected to a Rand air compresser, and installed in Alaska by the Tredwell Gold Mining Company; a 500-horse-power engine sold to the Colemanville Water & Power Company, of Colemanville, near Lancaster, Pa., and a 500-horse-power engine purchased by the Excelsior Powder Company, of Kansas City, Mo.

One of the three 8000-H. P. Westinghouse - Parsons steam turbines which are being built by the Westinghouse Electric & Manufacturing Company, at East Pittsburg, for the New York & Long Island Railroad was recently tested at the Westinghouse works in the presence of a large number of engineers. The test was conducted successfully, the machine being operated at its full capacity of 5500 K. W., or 8000 H. P., running 750 revolutions per minute. Including the generator, the dimensions of the turbine are:—Maximum length, 47 feet 3½ inches; width, 15 feet 8 inches; height, 14 feet; total weight, exclusive of generator, 350,000 pounds; weight of revolving element, 47,600 pounds. It is of the regular Westinghouse-Parsons construction and is the largest ever built.

The fire which recently damaged one of the Fay erecting shops of the great Fay & Egan woodworking machinery plant at Cincinnati, Ohio, will cause no delay in filling their orders as usual. A large part of the force of men employed in the shops have already resumed work and the remainder have been transferred to the Egan shops and their regular work continued as if nothing of the kind had occurred. Provision for just such a possibility had been provided for by the system under which this company is handled.

The Northern Electrical Manufacturing Company, of Madison, Wis., have been awarded the contract for the entire motor equipment of the new shops of the Southern Railway Company, at Spencer, N. C., which were designed by S. D. Cushing, signal and electrical engineer of the Southern Railway Company. Motors aggregating about 450 horse-power will be required. A combination of group and individual drive will be used, and all motor-driven tools requiring speed variation are to be equipped with Northern two-wire, variable-speed motors. The company will also furnish a 50-K. W. generator for lighting the shops of the Southern Railway Company at Alexandria, Va.

The American Conduit Company, of Chicago, has been awarded a contract by the Electrical Commission of Baltimore to supply that city with 200,000 feet of bituminized fiber conduit for underground construction. This contract was awarded after a series of exhaustive tests and investigations.

The National Electric Company, of Milwaukee, and the Hooven, Owens, Rentschler Company, of Hamilton, Ohio, offer an opportunity to purchase their exhibit at Block 46, Machinery Building, Louisiana Purchase Exposition. This unit consists of a revolving field alternator of 1500 K. W. capacity, direct connected to a Hamilton Corliss vertical, cross - compound, condensing engine, running at 83 revolutions per minute. The entire equipment represents the latest development of engineering design, and may be seen in operation until the close of the exposition. A detailed description, with illustrations, will be mailed upon request, and the representatives of the above firms may be found at Block 46, Machinery Building. The National Electric Company

may also be interviewed at Section 6, Electricity Building, where a nummer of other direct and alternating units of smaller capacities are to be disposed of.

C. H. Bradley, Jr., & Co., of Pittsburg, are exhibiting in the Machinery Building at the St. Louis Exposition a triple-expansion engine in which the steam ports and valves between the three tandem cylinders are located in the common piston rod. There are two sets of cylinders, the cranks on the common shaft being set at right angles. The engine on exhibition is used in the Exposition arc lighting service; it is built on the metric system throughout. The condensing apparatus consists of a 2000-square-foot Worthington condenser, a Blake vertical, twin-beam, air pump and an 8-inch Worthington volute circulating pump.

The Electric Controller & Supply Company, of Cleveland, recently received an order, which is nearing completion, for a complete system of magnetic switch control for five unloaders at the Lackawanna Steel Company's plant at Buffalo. The Electric Controller & Supply Company's magnetic cushion type solenoids are used throughout for the brake system for all motions for these unloaders. They also report an order from the New York Central & Hudson River Railroad Company's West Albany shops for a direct motor drive for a 60-inch planer. This new motor drive was recently put upon the market after being thoroughly tested and proving itself capable, it is claimed, of increasing any metal planer's output at least 100 per cent. Other advantages of this individual motor drive are the efficiency and flexibility in the distribution of power, clear headroom and freedom in locating tools to best advantage. A variable-speed motor is used and a speed controller is provided for securing the most efficient speed for cutting the work in hand.

New Catalogues

A catalogue devoted to measuring tapes, steel rules, and board and log rules has been sent out by the Lufkin Rule Company, of Saginaw, Mich. A number of types of steel tapes graduated in inches, feet, links and meters, are illustrated and described, together with a variety of machinist's, draughtman's and architect's steel scales. The booklet also illustrates and describes a steel pattern rule for measuring the length of curves for elbows, for oval, cylindrical, cone-shaped vessels, and the like, in tin and sheet-metal work. Illustrations of rules, gauges and calipers used in lumber work are also given.

Wire-rope tramways are treated of in a new catalogue sent out by the A. Leschen & Sons Rope Company, of St. Louis, Mo. The booklet deals with the distinguishing features and advantages of the several systems of wire-rope tramways of the company's design.

A new catalogue sent out by the Magnolia Metal Company, of New York, discusses the advantages of Magnolia anti-friction metal over other bearing metal compositions. Illustrations are given showing the effects of various loads on Magnolia and other bearing metals. Tables of properties of various metals are given and of the limiting pressures per square inch on various bearing surfaces. Cross sections of several types of machine bearings show the use of Magnolia metal therein. Complete directions for the use of the metal are given, together with tabulated data of tests by engineers, manufacturers and the United States Government.

Electric hoists, winches and capstans for direct and alternating-currents are illustrated and described in a new catalogue sent out by the C. W. Hunt Company, of West New Brighton, Staten Island, N. Y.

"Single-Phase Power Motors for Electric Lighting Stations," is the title of a paper read by W. A. Layman at the recent convention of the National Electric Light Association, and sent out in pamphlet form by the Wagner Electric Manufacturing Company, of St. Louis, Mo. The paper sets forth the advantages of the single-phase system of power distribution from central lighting stations.

Particulars of tests made by J. E. Denton and William Kent of De Laval centrifugal pumps have been issued in pamphlet form by the De Laval Steam Turbine Company, of Trenton, N. J.

A map showing the electric power transmission lines in California operated on the "S.K.C." system has been sent out by the Stanley Electric Manufacturing Company, of Pittsfield, Mass. The lines indicated on the map are those of the Standard Electric Company and the California Gas & Electric Corporation, both the finished and proposed lines of the latter company being shown. The longest transmission is that of the latter company between the De Sabla power house and Sausalito, a distance of 232 miles. The Standard Electric Company's longest transmission is that between the Electra power house and Mission San Jose, a distance of 147 miles.

A new catalogue sent out by the Cooper Hewitt Electric Company, of New York, is devoted to the Cooper Hewitt mercury vapor lamp. The pamphlet describes the main features and advantages of the lamp, and illustrations are given showing its application to various commercial uses.

The Power Installation Company, of Buffalo, N. Y., have issued a pamphlet illustrating some of their installations of electric power plants, electrolytic plants, factory and mining equipments, briquetting plants and elevating and conveying machinery. Many of the illustrations are prints from photographic negatives, the remainder being well-executed half-tones.

Steam-turbine direct-connected dynamos are illustrated and described in a new bulletin sent out by the De Laval Steam Turbine Company, of Trenton, N. J. The main features of the dynamos are described and illustrated, and several views are given showing both single and double generators connected to De Laval turbines. The pamphlet also contains illustrations of a turbine alternator, a turbine - driven series centrifugal pump and a motor-driven centrifugal pump. Another bulletin issued by the company is devoted to De Laval turbine blowers.

A new bulletin issued by the General Electric Company, of Schenectady, N. Y., is devoted to Thomson horizontal edgewise instruments for switchboard service. The pamphlet illustrates and describes ammeters, voltmeters, single-phase and polyphase wattmeters, frequency indicators and power factor indicators. Another bulletin by the same company illustrates and describes front-connected lever switches. Particulars are also given of push-button switches for printing-press motors and insulating joints for insulating two adjacent sections of pipe.

A new catalogue devoted to steam valves has been sent out by the Chapman Valve Manufacturing Company, of Indian Orchard, Mass. Illustrations are given of various types of bronze and iron body valves for high and low pressure and for use with superheated steam, one of the latest developments, the electrically-operated valve, being also illustrated. The illustration given is that of a gate valve, the motor being mounted on the yoke and geared to the threaded spindle. The pamphlet also contains a list of users of Chapman valves.

Depreciation on Electric Railways

By W. E. HARRINGTON, General Superintendent of the Public Service Corporation of New Jersey

THE growth of electric railways in the United States has been phenomenal when it is considered that the amount of money invested in railway properties aggregates $2,167,634,077 under Construction and

FIG. 1.—A DECAYED CORNER POST OF A TROLLEY CAR

Equipment account. The extent of this investment cannot be properly realized, owing to the large amount represented.

The last United States census reports are quite explicit in detail as to railway construction, cars, tracks, overhead line, car houses and power stations. The report shows that there were 66,784 cars, 21,920 miles of track and 1,204,238 H. P. in generators.

The amount of material required to maintain and operate the systems represented in the above is stupendous. The usual wear and tear incident to maintaining equipment for regular operation is provided for under operating expenses, and so appears in the financial reports of the various railways. This amount clearly covers renewal of car wheels, bearings, trolley wheels, rewinding armatures, renewing field coils, repainting cars, petty wood work repairs and kindred repairs. The car, truck, electrical equipment, track ties, overhead line, poles, power station apparatus, bridges, paving, buildings, etc., in the course of time arrive at a condition that despite the repeated repairs, must be considered purely as scrap, and in any event are abandoned in so far as further use is concerned.

The handling of this kind of wear and tear, known as "depreciation," is one that has never been squarely met and provided for in a large number of railway properties in their accounting systems. An investor may be sorely deceived, and readily too, if every side of this question be not thoroughly understood by him.

If the financial scheme of a property does not contemplate in its entirety the provision for depreciation, the day of reckoning will come when equipment entirely worn out will have to be renewed, with no financial provision for such renewal.

The natural outcome following a lack of such a system usually results in a more rapid depreciation than would follow if such a system were in effect, brought about by the desire of a management to make the best results at the time, regardless of the condition of the equipment in following years. The best illustration of providing for depreciation is that of car trusts. For instance, a series of cars are purchased and the money for them is paid off in, say, ten annual payments. At the expiration of the ten years the cars are fully paid for and practically have reached the end of natural life. The annual payments if made out of operating expenses would wipe out the account and the cost of the cars would not stand on the books as a fixed charge.

The chief problem involved in the question of depreciation is in arriving at what constitutes the life of any price of apparatus or construction. This is complicated by the fact that the experience with apparatus of yesterday is not that which would apply to apparatus of to-day. As our fund of knowledge increases, our experience broadens, with corresponding improvement in detail in the construction of the various kinds of equipment and a marked increase in the life of the part or apparatus.

However, certain fundamental facts exist. For instance, the life of a wooden tie under given conditions is to all intents and purposes a fixed constant. A car constructed of wood, we know, reaches its limit of life between twelve and fifteen years. As an illustration, Fig. 1 shows the rotting process of an ash corner post of a car twelve years old that had been going on insidiously under cover, not noticed, until the ends of the car gave way, causing the ends to drop out of alignment about 4 inches. Upon close examination, the wood work entering in the construction of the sills and frame work, particularly around the joints, was found in such a condition that the estimate for placing the car in fair operative condition made it un-

FIG. 2.—A DECAYED TROLLEY POLE NINE YEARS OLD

wise to incur such an investment. The car therefore, was scrapped, to obtain for it such a scrap or salvage value as was possible.

Again in the matter of trolley poles, Fig. 2 shows a yellow pine pole after nine (9) years of life barely able to stand the process beginning immediately at the ground and working up into the heart of the pole. Short life in street railway construction has become a very serious question to those

interested in the management of railway properties. To the builder of railways who is in charge of the operation for only a short time after construction this question does not especially appeal. In the question of treating processes for increasing life of the wood or the use, iron cannot receive too careful attention as the investment cost should go hand in hand with that of depreciation.

The wearing out of track construction is one that particularly appeals to the railway manager. It may surprise some to hear that under the ordinary conditions in traffic as is the experience upon the average railway property, the wear and tear incident to vehicular traffic is greater than that due to the car movement. However, the life of a track is to a great extent affected by the life and character of wear at its joints.

Fig. 3 shows the typical wear of a rail joint where the receiving rail is hammered down, making a serious defect in the track and necessitating practically the rebuilding of the line of track. In connection with the question of wear of joints is the old question of opposite and staggered joints. Experience dictates that where track work is employed, without paving, and the track may be readily and inexpensively kept in alignment, staggered joints are permissible, but when track is closed, and paving is used, then, and only then, should opposite joints be permitted. Observation shows that staggered joints, where in use in paved streets, and in use for some time, results in the track wearing out in places along the inside of the head of the rail, occasioned by the throwing of the car from side to side following the oscillating motion of the car produced by such staggered joints.

FIG. 3.—TYPICAL WEAR AT A RAIL JOINT

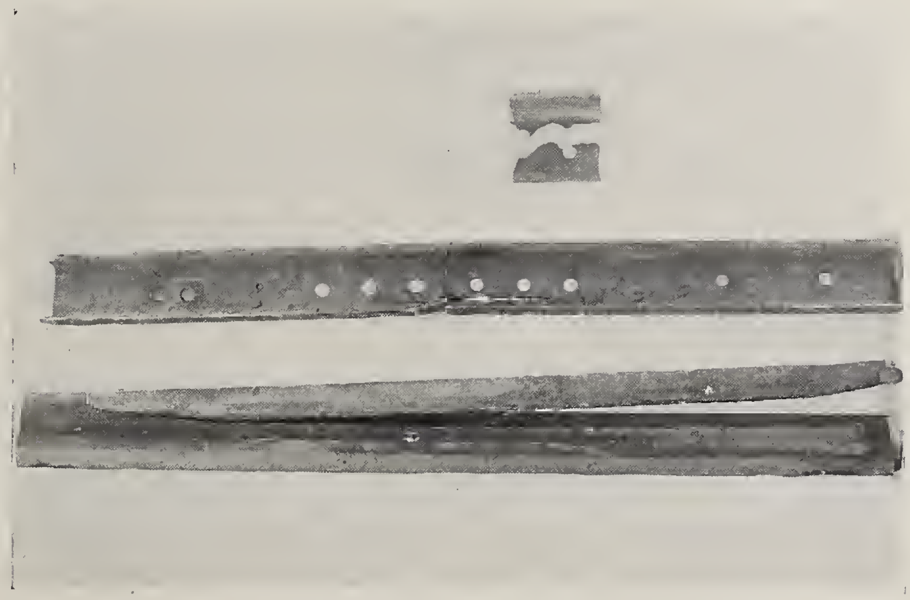


FIG. 4.—A WORN-DOWN RAIL HEAD

The frogs are a most fruitful source of expense. Fig. 5 is a cut of an ordinary crossing of a steam railroad track by a trolley track. In this particular instance the crossing had been renewed three times in five years at an expense each time of $2000. The last crossing place cost $3000, having hard steel renewable centers. This additional expense of 50 per cent. was incurred in the belief that the life would be increased at least 150 per cent.

The wear of rails is not only confined to the head and joints, but also manifests itself in the tread, cutting through as the head wears down, as shown in Fig. 4, which also illustrates the breaking away of the rail through the joint holes. The wear of tie plates, spikes and bolts is shown strikingly in Fig. 6.

The life of the parts illustrated has not been over eleven years. The wear of trolley wire is erratic; curves and special overhead work usually wears out in about one-quarter the time that straight work does. The usual life of trolley wire, No. 00, cannot be said to exceed twelve years with cars running on a ten-minute headway.

FIG. 5.—CROSSING OF A STEAM AND A TROLLEY TRACK

In a desire to create a longer-life-trolley some years ago, a prominent manufacturer of trolley wire placed what he called a "Bimetallic" trolley wire upon the market. This wire had a steel center, with a copper sheath (Fig. 7). The top wire, apparently split, is a piece removed after seven years of service. This, most happily, illustrates the idea of adopting the greatest care in not changing methods of construction to increase life, as the life of this trolley wire was at least 30 per cent. less than that of standard wire, and cost considerably more upon the score of reduced conductivity.

The shortest wire in Fig. 7 shows full-size trolley wire; the middle one

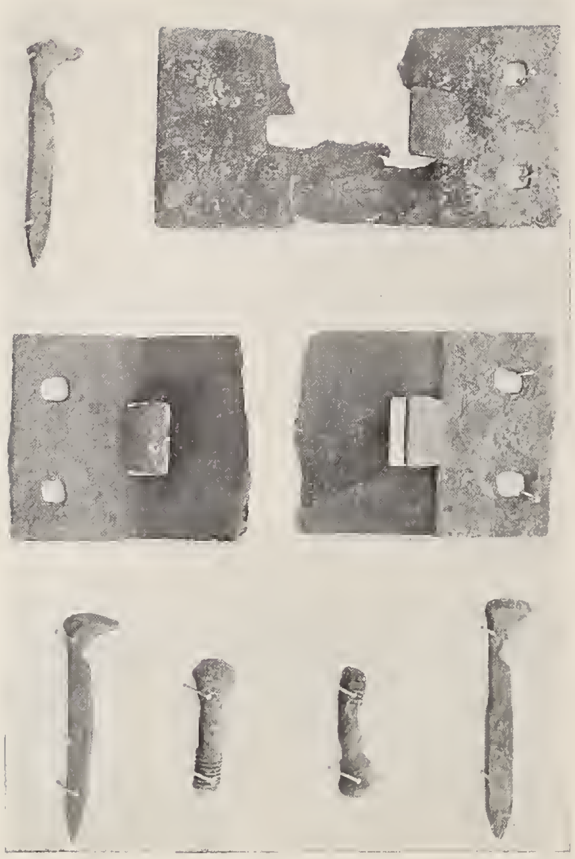


FIG. 6.—WORN TIE PLATES, SPIKES AND BOLTS

illustrates a piece of trolley wire cut out of a line in use ten years. This wire was drawn down to almost a tapering pencil point.

The average life of parts entering into the construction of electric railways, according to various authorities, with the percentage of first cost to be charged off annually, is shown approximately in the following table:—

Part or Detail	Average Life Years	Per cent Original Cost
Car body—ordinary trolley	13	7.7
Car body, best made passenger coach	16	6.2
Trucks	10	10
Electrical Equipment	15	6.6
7-inch girder rail, 10 minute service	9	11
9-inch girder rail, 10 minute service	12	8.3
70-pound T-rail, 10 minute service	15	6.6
Chestnut ties	7	14
Cedar	9	11
Hemlock	5	20
White Oak	7	14
Spruce pine	5	20
Shingle roofs, white cedar	40	2.5
Shingle roofs, cypress	19	5.2
Shingle roofs, warm climates	9	11
Corrugated iron roof, Camden, N. J.	5	20
Slag roof	15	6.6
Brick buildings	50	2
Trestles, white oak	25	4
Trestles, yellow pine	10	10
Lumber constantly under water	indefinite	—

The study of wear and tear attending the current operation of an electric railway is exceedingly interesting.

The determination of the actual weight of that portion of any given part or detail actually worn away in order to arrive at the cost per pound of the part destroyed by wear, developes the fact that material for such wear is quite expensive. Table I. following is taken at random from a few of the more important details used in current operations.

In conclusion, the recognition of depreciation, wear and tear, should, and will of necessity, assume a larger place in the economic study of practical operation of electric railways.

TABLE I.—COST OF WEAR

Name of Part	Weight New lbs.	Weight New oz.	Weight Worn lbs.	Weight Worn oz.	Weight of Worn off lbs.	Cost of New each	Value of Scrap lbs.	Cost of Worn off
Trolley wheels	2	2	1	10	½	$0.70	10c.	$0.538
Kalamazoo trolley harp	2	9	1	4	1 5/16	0.75	½c.	0.744
Pinion	33	..	31	..	2	2.85	½c.	2.695
Pinion	17	..	14	3	2 13/16	1.98	½c.	1.910
Pinion	32	..	31	..	1	2.85	½c.	2.695
Brake shoes, large	36	..	26	..	10	0.925	½c.	0.795
Brake shoes, small	30	..	26	..	4	0.65	½c.	0.520
Brake shoes	35	..	23	..	12	0.88	½c.	0.765
Brake shoes	25	..	15	8	9½	0.88	½c.	0.802
Brake shoes	25	..	15	..	10	0.88	½c.	0.805
Brake-shoe hangers	2	10	2	8	⅛	0.25	½c.	0.237
Brake-shoe hangers	2	9	2	5	¼	0.20	½c.	0.189
Brake-shoe holder	11	4	9	10	1⅝	0.75	½c.	0.702
Motor-axle bearings, 4-in.	15	10	5	..	10⅝	4.00	½c.	3.975
Release springs	3	11	3	7	¼	0.40	½c.	0.383
Solid motor-axle collar, 3⅝-in.	9	14	8	1	1 13/16	0.29	½c.	0.247
Motor-axle collar, 3⅝-in.	19	5	5	..	14 5/16	2.82	½c.	2.795
One-half elliptic spring	29	8	20	8	9	3.00	½c.	2.897
Bevel gear, small	2	..	1	9	7/16	0.234	½c.	0.227
Bevel gear, large	3	5	2	15	⅜	0.402	½c.	0.388
St. Louis shoe holder	19	..	14	8	4½	0.669	½c.	0.597
Spring cap	1	..	..	12	¼	0.10	½c.	0.097
Shoe hanger	3	..	2	4	¾	0.25	½c.	0.239
St. Louis bearing	5	8	3	7	2 1/16	0.925	½c.	0.908
St. Louis journal-box lid	2	12	2	..	¾	0.30	½c.	0.290
Shoe holder	4	..	3	13	3/16	0.30	½c.	0.281
St. Louis release spring, large	7	8	7	3	5/16	0.50	½c.	0.465
Com. bearing	10	6	8	10	1¾	1.98	½c.	1.937
Pin. bearing	10	11	10	5	⅜	1.62	½c.	1.569

The past decade has been one of development; the future will, by reason of the high development and efficiency of the apparatus employed, be one wherein both the operating manager and the accountant will have to study the life and probable depreciation of the construction employed in order to arrive at a point to obtain the longest life with a minimum expenditure. The writer is familiar with at least three organizations who have in the last few years grappled with this problem and who lay out not only their construction, but also have their system of accounting designed to thoroughly provide for this important question. These are the Milwaukee Electric Railway and Light Company, United Gas Improvement Company, and the Public Service Corporation, of New Jersey.

The writer does not know of any case of municipal ownership where this question has even been considered, let alone making provision for it either in construction or in accounting.

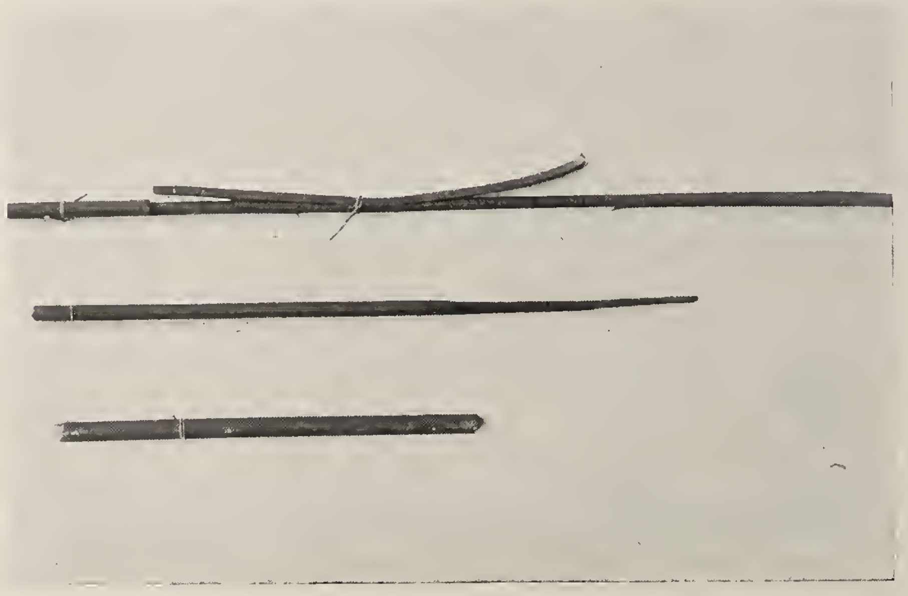


FIG. 7.—TROLLEY WIRE SPECIMENS

New Fields for Rubber Growing

THE growing of Para rubber in the Malay States, according to investigations made by O. F. Williams, United States consul-general at Singapore, is not only proving successful, but in the future is likely to command the world's attention. The growth is continuous and, when the trees are cared for, is amazingly rapid, as heat is perpetual and rains frequent. As the Philippine Islands are in the same latitude and have superior soil, Mr. Williams suggests that everything be done to encourage the development of rubber plantations.

A magazine arc lamp, recently brought out in England, is fitted, as its name implies, with a magazine containing several carbons to be used successively. The magazine is a cage revolving on a vertical axis, and is capable of holding twelve carbons.

THE ELECTRICAL AGE

Established 1883

Volume XXXIII Number 5
$2.50 a year ; 25 cents a copy

New York, November, 1904

Entered at the P. O. as 2d-class matter. Copyright, Louis Cassier

Electrical Display at the Knights Templar Conclave

At San Francisco, September, 1904

By H. W. JUMPER

THE CENTRAL FIGURE OF THE ILLUMINATION WAS A HUGE ELECTRICAL BELL ON MARKET STREET, 20 FEET IN DIAMETER, MADE UP OF EIGHT THOUSAND 16-CANDLE-POWER INCANDESCENT LAMPS

THE twenty-ninth triennial conclave of the Knights Templar, held at San Francisco, Cal., in the early part of September, afforded a splendid demonstration of the decorative capabilities of the electric incandescent lamp.

The decorations, probably the most elaborate ever held in this country for the short period of time they were used, were a combination of intricate and elaborate electrical displays, evergreen and the national colors. There was a noticeable absence of cheap bunting. The principal decorative scheme was obtained by the use of the electric light—thirty thousand 16-candle-power equivalents being used, at a cost of installation of nearly $20,000.

The central figure of the illumina-

THE COURT OF HONOR.—THE ART GALLERY OF THE PAVILION IN WHICH THE CONCLAVE WAS HELD

MARKET STREET, SAN FRANCISCO, WAS A BLAZE OF LIGHTS FOR A DISTANCE OF TWO MILES

tions was a huge electrical bell situated at the juncture of Third, Market and Geary streets, between the tall buildings of the "Call," "Chronicle" and the "Examiner"—San Francisco's three daily papers. These buildings were likewise gayly illuminated. The bell was composed of a central ring 20 feet in diameter, suspended 100 feet above the street by two $1\frac{3}{4}$-inch steel cables. Eighty feet below this ring and suspended from it was a second ring, 90 feet in diameter. Completely filling the upper circle was a large passion cross and crown and the motto of the Templars, "In hoc signo vinces,"set solid in colored electric lights. Connecting the upper and lower rings were thirty-six long streamers of 16 candle-power lights, with sixty-five lamps to a streamer. The lower ring was a blazing circle of light, and suspended from it were large emblems of the order, also in colored lights. There were eight thousand 16 candle-power lights in the bell and mottoes. The weight on the two suspension cables was about 9 tons.

The Union Ferry Building, with its tall, graceful tower, was a dream of light. The graceful lines of the tower were picked out in lamps of emerald green, with a huge Maltese cross in red suspended on each of its faces. From the Ferry Building to Polk street, a distance of two miles, Market street was a blaze of light. Each side of the street was set with tall flag poles placed 50 feet apart. Each of these supported two large circular clusters of flags surmounted by a larger flag. The poles were in pairs, connected by festooned streamers across the width of the 100-foot street, each streamer containing thirty-seven 16 candle-power lights.

The word "Welcome," outlined in lights and occupying the full width of the street, was suspended about 300 feet from the Ferry Building. An electrical arch was placed a little further up the street. This contained five hundred and twenty-five lights. A similar court was placed at Sixth and Market streets. This had two thousand five hundred 16 candle-power lights in the composition. The Masonic Temple had two thousand five hundred 16 candle-power lamps used to ornament its front.

Besides the Templar illumination, the city used five thousand lights to illuminate the dome of the City Hall. The lights in the Ferry tower were furnished by the State. Both sides of Market street were dazzling rows of light, with hundreds of signs and emblems in white and colored lights displayed by private firms. Some of the business blocks were illuminations in themselves.

The pavilion, where the conclave was held, was decorated at a cost of $40,000. In the main hall the roof was hidden by a huge canopy made from 3000 yards of unbleached muslin. This formed an excellent background for the long streamers of light and the colored emblems everywhere displayed, but made it so dazzling that it was impossible to photograph the lights to advantage. Five thousand lights were used in the illumination scheme of the hall. To fireproof the large amount of cloth used, as well as the other inflammable material of the decorations, a special plant had to be put up to put the work through on time.

Sixty carloads of evergreen trees were used to decorate the hall. Forty carloads of these were carried in wagons over the mountains in Mendocino County, and then shipped 150 miles by rail to San Francisco. A miniature forest at one end of the gal-

THE DOME OF THE SAN FRANCISCO CITY HALL WAS ILLUMINATED BY FIVE THOUSAND LIGHTS

leries contained trees from 30 to 40 feet high, and in this mimic wild the courts of Mendocino entertained. San Jose Commandry sent ten carloads of potted plants and palms 50 miles from their home town to decorate their parlors. Eureka had a parlor furnished in polished redwood—the panels in the wall were solid boards 6 feet by 12 feet, and all the furniture in the room was redwood, polished and finished in the natural color. The columns supporting the galleries were covered with redwood bark, with arches and ceiling of redwood boughs; around the columns and through the limbs were scattered numberless lights like glittering stars.

The art gallery of the pavilion was transformed into a grand court of honor, and was one of the main attractions, words of praise coming from all who visited it. Here were held the receptions and promenades. The floor and walls were covered with green burlap. The ceiling was tinted cream color. Along the sides were tall fluted columns of white, surmounted each with a plaster cap holding a large eagle. The cap and eagles were finely finished, and weighed about a hundred pounds a piece. The eagles were backed with beautiful American flags. It took 2000 yards of burlap to cover the walls and floor of the court.

The approaches at each end of the court were through masses of evergreen. Two beautiful fountains marked the entrance. These were modeled for the occasion by Miss Nonetta McGlashen, a local artist of promise. The entire decorations were handled by Messrs. Deckner & Dill, of San Francisco.

The electric work was sublet to Hetty Bros. and the Novelty Sign Company, also of San Francisco, and their work showed their ability to handle such large contracts.

Current for the illumination was furnished by a General Electric 1500-K. W. generator, specially installed for the illumination.

The current was transmitted from the Potrero power house of the San Francisco Gas & Electric Company to its substation at Eighth and Market streets, over a reserved cable at a voltage of 11,000. There it was stepped down to 2200 volts and distributed to the different sections of the streets. For the street lights it was stepped down from 2200 volts at every block, no feeders being over 500 feet in length.

It might be worthy of note that all the colored signs and emblems used were of metal, fitted with weather-proof sockets and put together as if for permanent use.

Electric Automobiles in British Post Office Service

THE successful use of electric automobiles for post office work in Great Britain is shown by the following extract from the report of the Postmaster-General:—

Some progress has been made during the past year with the use of motor vans for the conveyance of mails. Mail services between the following towns are at present being performed by means of motor vans:—London and Epping, London and Redhill, Manchester and Liverpool, Sunderland and Newcastle, and Birmingham and Warwick. Several motor vans are also being used on mail services in London. The best results have been obtained on the service between London and Epping. A Milnes-Daimler motor van has been employed on this service, and it has kept excellent time and has had no serious breakdown.

An elevated moving sidewalk system has been spoken of as a possible relief for London's heavy street traffic.

Direct-Current Switchboards

By BERTRAND P. ROWE

IN the early days of electricity, incandescent lighting plants were the first in which measuring instruments and switching apparatus became essential. As the voltage was low, a wooden panel or the side wall of the station usually formed a primitive switchboard on which the apparatus was mounted. The objections of the fire insurance companies and the fires resulting from the use of inflammable material in the construction of switchboards finally forced wooden boards out of service.

Experience has shown that a switchboard must fulfill the purposes of measuring and of controlling the circuits, that it must be made of fireproof insulating material, and be constructed with a view to maximum safety to the attendant and the elimination of dangers of fire due to opening of circuits.

The best material used for switchboard panels is marble. Its adaptability was early recognized, and among the first switchboards of any size we find many of white Italian marble. Good slate, free from conducting veins, is an excellent material for low-potential work, but it cannot be depended upon for insulation, as it often contains resistance circuits which appear when the voltage is sufficient to develop them. It is also liable to absorb moisture. When enameled or marbleized, it is rendered less absorbent and presents a very pleasing appearance.

A black-enameled slate switchboard is eminently suitable for railway work or in any station where oil is liable to get on the panels. The slate panel is as good as ever after the oil is wiped off, while with marble the oil is absorbed, making a bad grease spot difficult to remove.

Of the many kinds of marbles, the white Italian, blue Vermont and Tennessee are most often used. The Vermont and Tennessee marbles are much softer than the white Italian, and are easily cut, but for the same reason are more easily scratched and damaged. They are often difficult to work, because pieces of flint frequently found in a slab of soft marble will cause the drill to run out. Another material now coming into use is Alberene stone, which is of the nature of soapstone and a very good insulator. It absorbs less moisture than slate.

The first step toward the modern switchboard was made when each

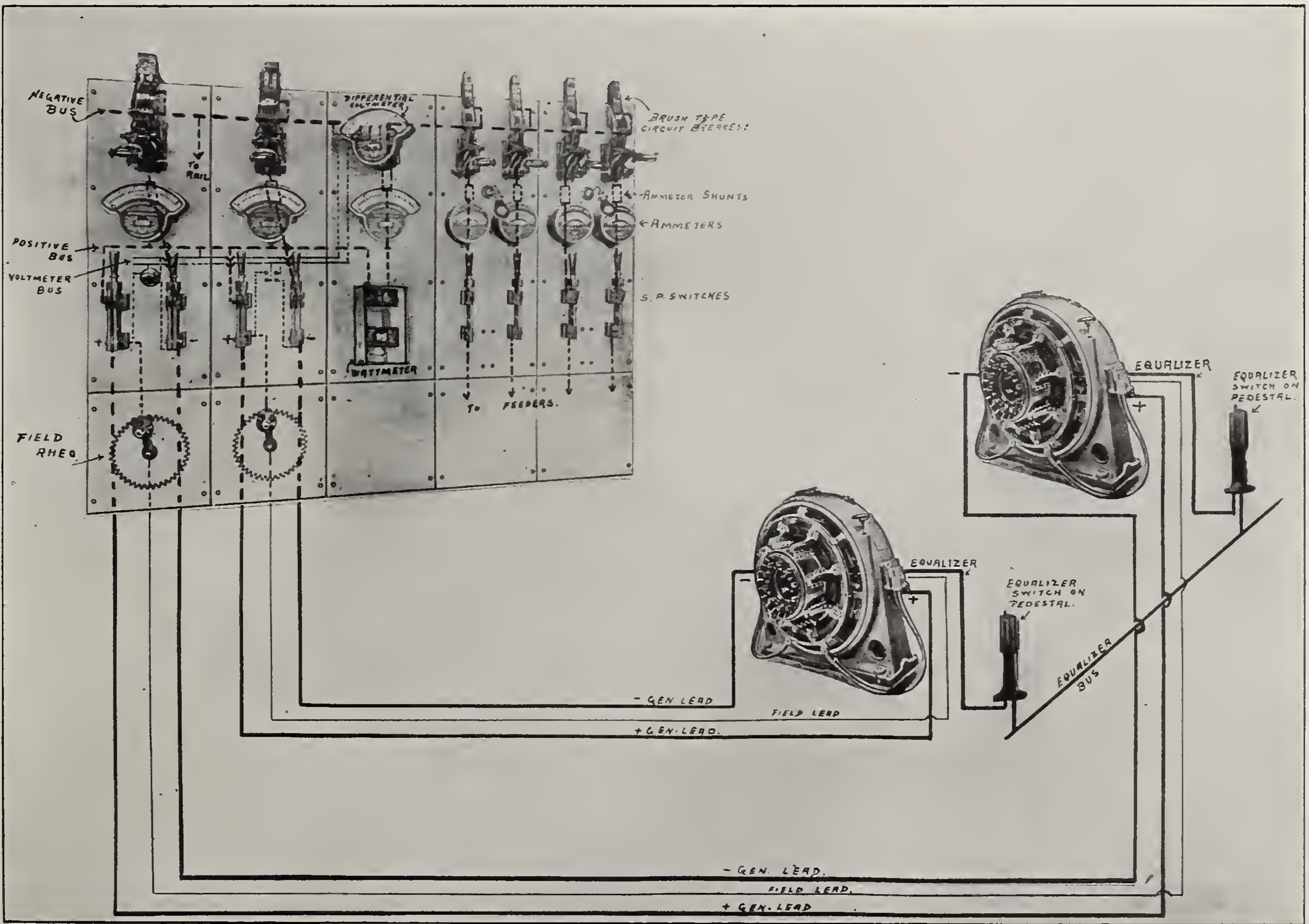


FIG. I.—A TYPICAL ELECTRIC RAILWAY SWITCHBOARD LAYOUT

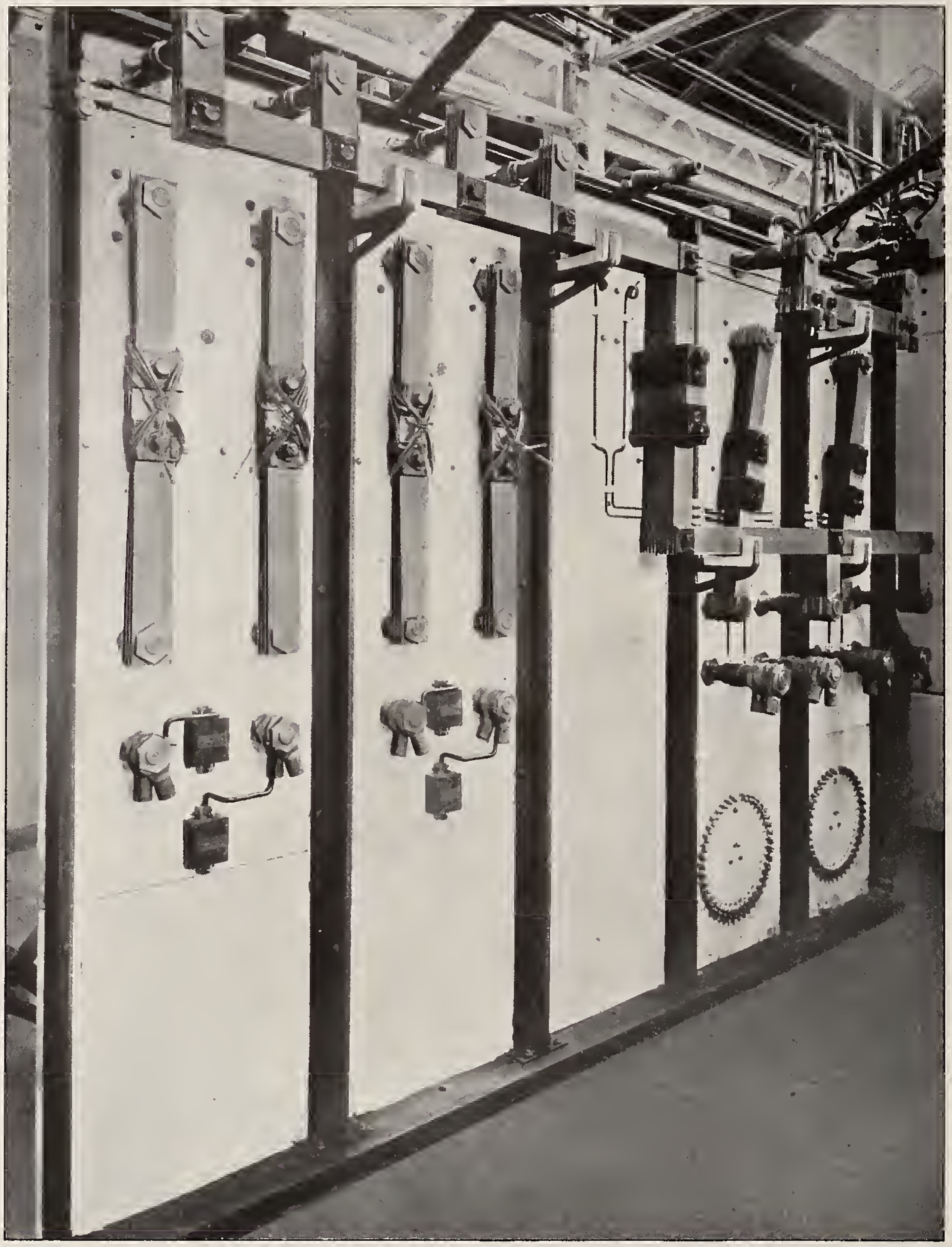


FIG. 2.—THE BACK CONNECTIONS OF THE SWITCHBOARD SHOWN IN FIG. I

piece of apparatus was mounted on a separate marble base. In some of the original marble switchboards these instruments, with their bases, were again mounted on rectangular panels of marble, grouped together and supported by an iron framework. This practice is still in vogue to some extent and is sometimes adopted if some special piece of apparatus is to be installed, so that it can be easily removed from the switchboard and adjusted or repaired without requiring that the work be done on a live switchboard panel. With such an arrangement a "jumper" can be inserted and the apparatus removed.

The next step in switchboard construction which was generally made, was the mounting of apparatus for the control of each generator or each feeder on single slabs of marble, with a foot panel below. This method, with various modifications, is the best present practice.

For bus-bars pure copper has been employed from the first, and is still the usual material, although aluminium has been tried for many small installations. The original practice, however, was to use round bars, while the present practice is entirely in favor of a rectangular section. The best practice is to provide a unit bar, several of which may be used in parallel whenever large capacities are required. Several sizes have been used, the most common sections being 10 inches by $\frac{1}{4}$ inch, 6 inches by $\frac{1}{4}$ inch, and 3 inches by $\frac{1}{8}$ inch.

A typical railway switchboard is shown in Fig. 1. In the latest practice the circuit breaker is sometimes mounted on a separate panel, forming a division on a line just above the ammeters. The general construction and the back connections are well illustrated in Fig. 2. From Fig. 1 it will be seen that an equalizer pedestal is provided near the generator, the equalizer bus-bar ,consisting of a short length of cable connecting the pedestals. This arrangement is always used for large generators. It saves copper connections; it also permits the equalizer circuits to be closed first and current established through the series field, helping the generator to build up its voltage quickly. With earlier railway switchboards using triple-pole switches, this result could not be accomplished

A modification of the connections is shown in Fig. 3, the difference being that instead of placing a single-pole circuit breaker in the negative circuit of the generator, the circuit is opened on the positive side. As the series coils and equalizer connections are on the positive side of the generator, a circuit breaker that will open both positive and equalizer circuits is required, as is shown in the diagram. Such an arrangement is used only on smaller generators.

The feeder panels of railway switchboards commonly have only the positive side of the circuit to control, as the negative side is usually connected directly to the grounded rails. There are various types of feeder panels. One in favor with some engineers is shown in Figs. 4 and 5, designed to control two small feeders through but one circuit breaker, instead of using two sets of instruments throughout.

Of late years the capacities of generators have increased and the switchboard practice common for small machines is often clumsy and more expensive than need be for larger units. The distance between generators and switchboard is often considerable, and the cost of conductors is a big factor in the installation. With the equalizer from the switchboard eliminated, it becomes feasible to eliminate the negative bus-bar and conections also. To this end a panel, which contains the switching devices for the negative lead, is usually provided at each generator. In this case the series coils are connected on the negative side of the generator.

If we place only the negative main switch and equalizer switch on this panel, leaving the ammeter, circuit breaker and positive switch on the main switchboard, there is a possibility of serious trouble if the positive side of the generator become grounded at the brush holder or anywhere between the generator and the circuit breaker. In such a case, it is, of course, important that it be possible to open the circuit by means of the negative switch. The safest way is to in-

sert a circuit breaker in the main lead from the negative brush holder of the generator to open the circuit automatically on short-circuit or unusual overload.

Fig. 6 shows a suitable arrangement of these connections. It will be noted erators were first installed, that the series field, and the shunt fields and generator frame, therefore, do not have to stand a great difference of potential.

It was a theory, when railway generators were first installed that the series coil ought always to be on the line side of the machine, so that they would act as choke coils to protect the machine against lightning discharge. However, the writer believes that no one considers this method of connections necessary for the generator of the present day. When the series fields are shunted by heavy German silver shunts to regulate the compounding, the series coils are rendered of no account as choke coils. Besides, with such heavy copper connections on the contact board, lightning would be likely to jump across the connections and shunt the series coil entirely. It is generally conceded, therefore, by most engineers, that there is no objection to the method of connections just described, especially if the feeder lines are well protected by lightning arresters.

If it be considered objectionable to permanently ground the series field, this can be avoided by changing the connections of the series coil and inserting a switch. Such an arrangement involves another connection from the panel to the generator, and being, therefore, less simple, is not usually adopted.

For this method of connection as shown in the above noted figure, the generator terminal board must be so arranged that the circuit breaker can be mounted as described. This involves no extra cost other than the extra panel with an extra circuit breaker. Which method is of less expense depends, therefore, upon the capacity of the generator and the length of the leads to the switchboard. There is a saving in copper conductors which must be balanced against the cost of extra apparatus.

As the circuit breaker at the machine is so distant from the switchboard, a tripping coil is usually provided, operated from a push button on the positive generator panel. The switchboard attendant has to depend upon some one on the main floor of the station to close the switch and the circuit breaker, unless they are provided with electro-magnetic closing devices.

It is worth noting that for years the common practice has been to depend upon a high-resistance in the field rheostat to cut down the field current of the generator, and to omit all devices intended to open the generator fields. It has also been considered that grounds between the brush holder leads and switchboard are not liable to occur in a plant properly installed, although there have been exceptions. For example, in one plant the hook of a traveling crane caused a ground by coming in contact with the brush holders, and the damage done was considerable.

If we believe that trouble of this sort is too remote to be taken into consideration, it might be suggested that we could omit the negative circuit breaker and depend upon the circuit breaker in the positive lead. This has been done by some engineers, and the negative and equalizer switches are often mounted directly on the generator frame. This method is really only a modification of the connection shown in Fig. 1, and requires the same appara-

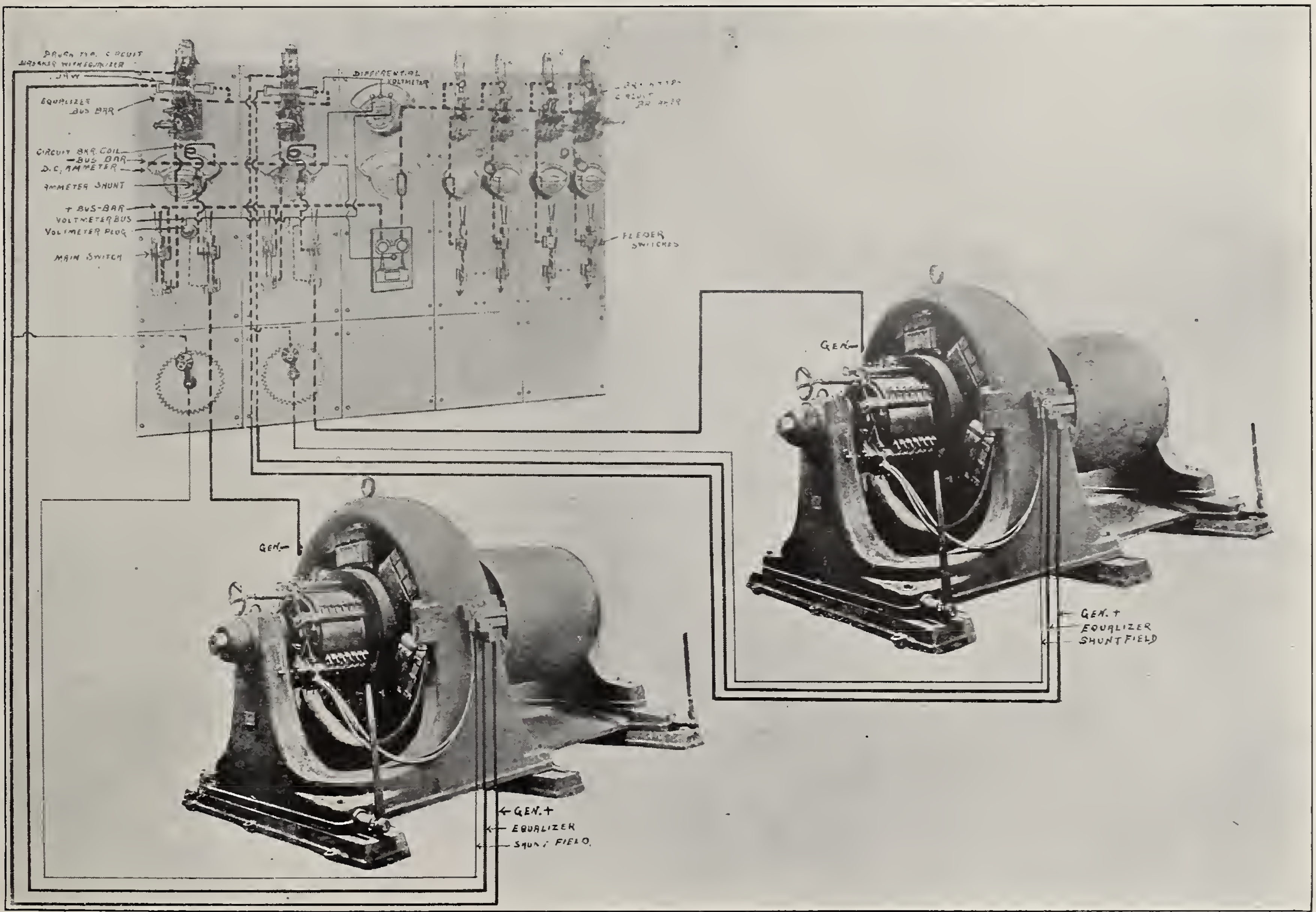


FIG. 3.—A MODIFIED FORM OF RAILWAY SWITCHBOARD

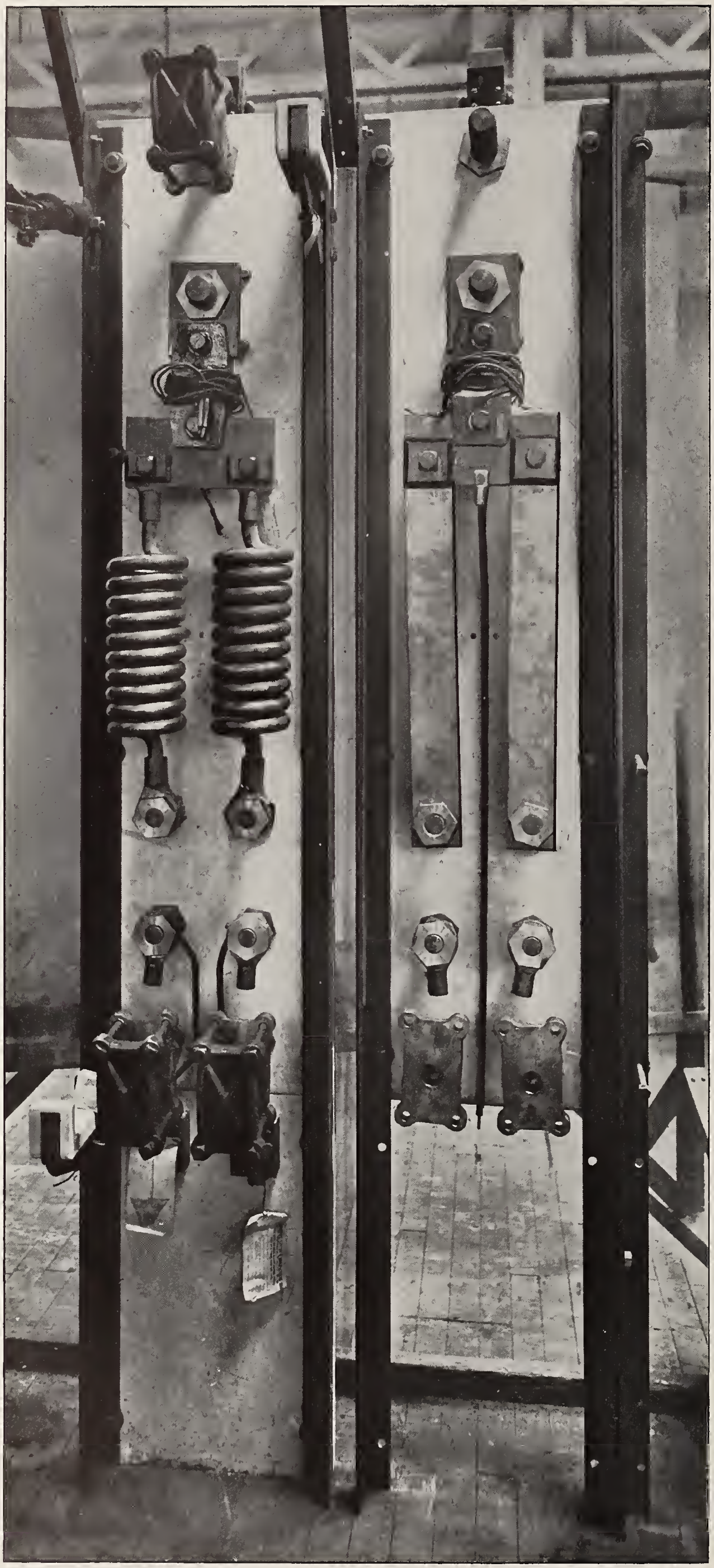


FIG. 5.—A REAR VIEW OF A SET OF RAILWAY FEEDER PANELS

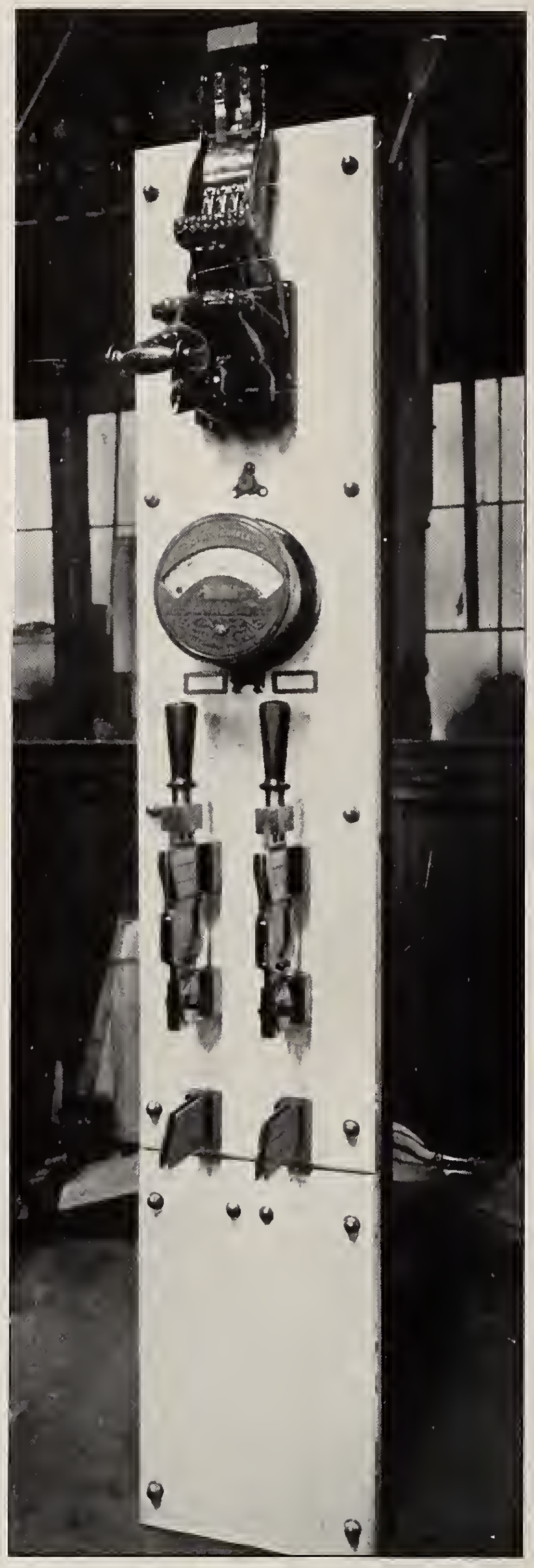


FIG. 4.—AN ELECTRIC RAILWAY FEEDER PANEL

tus usually supplied for direct-current generators, except that the two switches mentioned are at the generator. It would, therefore, be as safe as the standard method except that there is more danger of short-circuiting the generator inside the circuit breaker, it being only necessary to ground the brush holder lead, the positive and negative connections in the standard method being obliged to come together to cause a short-circuit.

The negative switch, however, can be omitted, if necessary, if a circuit breaker be used. This is done in the Lincoln Wharf Power Station, of the Boston Elevated Railway. Such a switch is a convenience, but not a necessity. The omission of the negative circuit breaker reduces the cost of such

an installation, but in the writer's opinion it is better to retain the circuit breaker and omit the negative switch, than to omit the switch and the circuit breaker also.

One advantage of such a scheme is that practically no insulation is needed on the negative leads or the negative panel. No one can get a shock if they touch either the bare equalizer or negative connections in the rear of the panels, although these are usually enclosed by an iron case for the sake of appearance. The whole being practically grounded, the expense of rubber insulation on the cables can be avoided.

It frequently occurs in direct-current street railway service that one or two long-distance feeders must be operated at a higher voltage than the rest of the system. This is usually accomplished by a series-wound booster driven by a shunt motor. The operation of such a booster set involves a few precautions.

If a dead short-circuit or heavy overload comes on the booster-fed feeders, the main generator breakers in the power station will undoubtedly open. If the shunt motor has an automatic release on the starting and stopping rheostat, this will immediately release and cut out the motor. If the power comes on the main bus-bars without the station attendant first opening the booster circuit, this machine will start up as a series motor and run at dangerous speed, as it is usually wound for only 200 to 300 volts, and will be driven from 500 or 600-volt bus-bars.

To obviate this and other difficulties a form of connection has been adopted by means of which the current for both the booster and the motor is taken from the bus-bars through the same circuit-breaker jaw. The coil of this breaker is calibrated to open automatically for motor overloads. A separate tripping coil is placed on the circuit breaker, which is connected across the bus-bars through a contact on the motor-starting and stopping rheostat. The releasing of the rheostat closes the contact and trips the circuit breaker. Any overload on the motor or an opening of its circuit will cut out both booster and motor, and the dangers of operation are reduced to a minimum.

The direct-current side of a rotary converter is connected up in the same way as described in Fig. 1 for direct-current generators. An interesting direct-current, rotary-converter switchboard is the type supplied for the Glasgow Corporation sub-stations.

The rotary converters each have a starting motor on one end of the shaft and a booster on the other.

The boosters were necessary on account of the regulations of the British Board of Trade, which did not allow a drop in the rail return of over 7 volts per mile. This is provided for by putting boosters in the rail-return circuits to raise the pressure. At first glance this would appear to require a booster in each rail-return feeder. Mr. H. F. Parshall, however, who designed this system, arranged the boosters with a plugging system, so that any booster armature could be connected to either of the four sets of bus-bars. The fields of these series boosters, however, are in series with the feeders which connect to the trolley circuits, so that be plugged on either of four sets of bus-bars, and the booster fields are similarly arranged. This makes it possible to adjust the voltage on the rail returns so as to be within the regulations of the Board of Trade without a large number of boosters, and it eliminates entirely the expense of separate driving motors. The connections are necessarily somewhat complicated.

The conditions of railway service in our country are not so exacting as those of England. The typical direct-current railway switchboard will serve, with very little addition, to control the direct-current side of rotary converters, as has been stated.

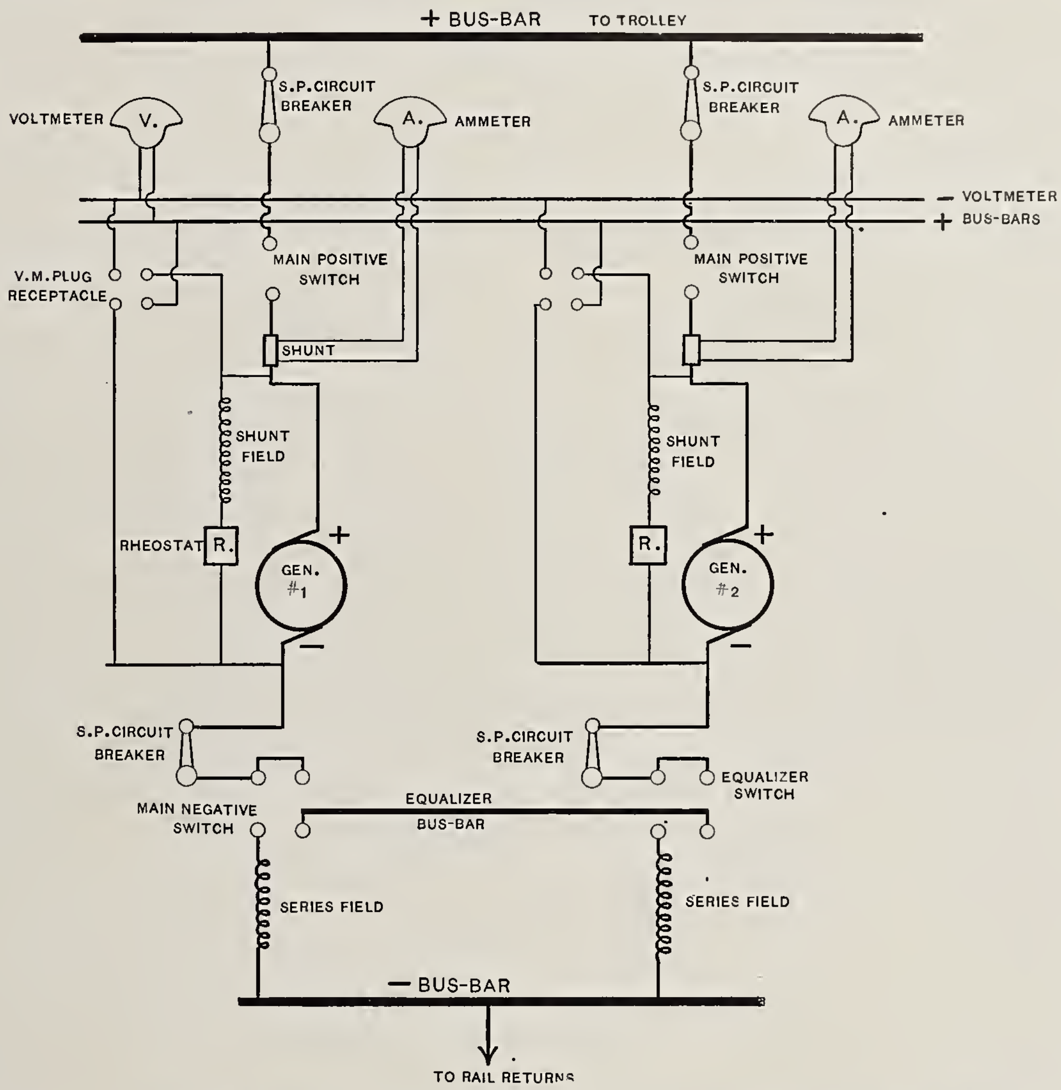


FIG. 6.—DIAGRAM OF CONNECTIONS FOR RAILWAY GENERATORS WHERE THE POSITIVE SIDE ONLY IS CONNECTED TO THE SWITCHBOARD

the load on the out-going feeders acted directly on the boosters to vary the voltage according to the load, and the booster armature circuits are capable of being connected to either of four sets of negative bus-bars, and the rail returns can be plugged to these bus-bars.

The fields of each booster also have a heavy capacity resistance connected so as to be in parallel with the fields, and other switches are provided, so that the fields can be partly shunted or short-circuited entirely if necessary. There are three steps in the resistance, so that quite a variation can be obtained. A plugging system was arranged so that any traction feeder can

A typical direct-current rotary-converter switchboard is shown in Fig. 7, which illustrates one supplied to the Third Avenue Railway Company, of New York, to control 1000-K. W. rotary converters. The Third Avenue Railway has no grounded return, and consequently each feeder panel has to control the trolley and the rail-return feeder. It will be noticed that each feeder has a full complement of instruments, and the switches are double-throw, to enable any feeder to be thrown on either the positive or negative bus-bar, thus reversing the polarity of the feeder. Whenever any sec-

FIG. 7.—A TYPICAL DIRECT-CURRENT ROTARY CONVERTER SWITCHBOARD

tion of either the trolley or rail-return feeders becomes grounded, this arrangement enables the station attendant to throw the grounded sections all on the same bus-bar and avoid serious delay in traffic. The rear view of this switchboard is shown in Fig. 8.

The main difference between the standard railway switchboard and the lighting and power switchboard lies in the use by the latter of a complete metallic return circuit without ground. This requires that the feeder panels have double-pole switches, instead of single-pole, and both positive and negative bus-bars. Fig. 9 shows the front view of such a switchboard for heavy service. The rear view is shown in Fig. 10.

The development of direct-current incandescent lighting was responsible for the Edison three-wire system, with two 110-volt generators operated in series as a three-wire, 220-volt generating set, with the middle or neutral wire connected between the two machines. One of the latest developments in this line is the Westinghouse three-wire generator. With this machine, a single 220-volt direct-current unit takes the place of the two 110-volt generators, and the neutral wire is connected through auto-converters or balancing coils to a set of collector rings on the armature shaft. A diagram of connections for such generators is shown in Fig. 11. The generators are 500-volt machines, and the light and power circuits are operated at 250 volts.

In an installation of this kind there are several very important matters to be taken into consideration. One of them is that the series field of the generator is divided into sections, one being connected to the positive and one to the negative side of the generator. This necessitates an equalizer on each side of the machine. It is obvious, therefore, as shown in the diagram, that circuit breakers must be provided which will open both the main and corresponding equalizer circuits simultaneously. As there are two circuits, a breaker is needed on each side of the machine.

Another important point is the measurement of current. The ammeter must be inserted where it will indicate the entire output of the machine, that is, in the brush holder lead. On the other hand, as the current from the neutral wire returns to the armature through the collector rings, it is evident that any unbalancing of the load will cause a difference in the currents from the positive and negative brushes making it necessary to supply two ammeters. It is obviously impossible to use meters of the series type for this purpose. The generators are, therefore, built with provision for a shunt to be mounted on the contact board, for use with a shunt ammeter. The leads of the meter are supplied of such length that the meters themselves may be placed in any convenient position on the switchboard.

The generators are usually made with four collector rings, and this necessitates two balancing coils, which have their middle points connected to the neutral wire. It is often convenient to have one or two generators take all the unbalanced load if it be not too great, and this can be easily done by leaving the balancing coil switches of the other machines open.

This condition is often found in a large plant where the unbalanced load is so light that only one or two three-wire generators are necessary. In such a case it is necessary that the two-wire direct-current generators which are to run in multiple with the three-wire machines have their series fields so divided that they will all compound alike. This is mentioned here because provision must be made so that the circuit breakers open the main and equalizer circuits on one side of the machine as just described. Only one ammeter, however, is necessary on each machine. The condition, in short, must be similar to that indicated on the diagram for one of the three-wire generators, except that one ammeter and one circuit breaker are omitted. In cases where the regular two-wire generators are already installed and the cables are already run in conduits to an existing switchboard, it becomes a problem how to get a suitable circuit breaker which will open the positive and equalizer circuits installed, without going to considerable expense. Of course, the provision for this equalizer must be made, and an easy solution is sometimes necessary for many reasons.

A simple method, although one which is only to be considered as an expedient, is to mount a single-pole circuit breaker on one side of the generator and connect it in the brush holder lead inside of the equalizer connection. This breaker will open the positive and equalizer lead on one side of the machine, although it will leave the other main and equalizer lead

in circuit. The circuit, however, is completely broken, and when the switches in the positive and equalizer circuits are afterward opened, there exists only the difference in pressure due to the drop through the series coils.

Another type which is being used extensively, and which will probably become more common as the art advances, is the switchboard for controlling electrolytic machines, one of which is illustrated in Figs. 12 and 13. The requisite for such a switchboard is great current capacity and accurate measurement of current and voltage.

As the generator capacity is great, there is little danger from short-circuits. As the load is usually transferred from one machine to another without suddenly interrupting the circuit, circuit breakers are seldom used. The negatives of all the machines are often tied together by heavy copper conductors which connect to the electrolytic tanks, and all of the switching is then done on the positive sides. This brings but one polarity to the switchboard and saves an immense amount of copper.

In heavy connectors the number of threads per inch is an important matter. The conductivity of the connection is not so good with a coarse thread as when a finer thread is used. For instance, studs 3 inches in diameter, with six threads per inch, are not so good for electrical purposes as those with twelve threads per inch, and for large studs twelve threads have been of late the regular practice. The reason for this is that the machinists who make the nuts and studs will not get exactly the correct setting of their thread tools, and the thread in the nut will not have the face of its thread at the same angle with the face of the thread on the stud. With a coarse thread under such conditions there is less chance of contact than with a fine thread. In the case mentioned, the twelve threads per inch have twice the chance of making contact, supposing the angle of faces to differ as described.

Another important point in such an installation is the use of copper of good conductivity and homogeneous. It has been found that large copper castings are very apt to be full of blow holes in the interior where they cannot be detected except by a specific gravity test or by cutting the castings in two. For this reason copper forgings are used, these being forged from ingots of pure copper, wherever possible, instead of being cast, and all busbars are of pure hard-drawn copper. A switchboard so made ought to carry its rated capacity with a rise of not over 20 degrees C. above the surrounding air when the conditions are normal.

With a very hot engine room it is to be noted that a rise of 20 degrees C. added to the heat of the air will make a piece of apparatus warm enough, and if the apparatus has to carry heavy overloads under such conditions, the point may be reached where copper switch jaws and other contacts will lose their temper and turn black.

As electrolytic plants usually operate night and day, month in and month out, they need especial care in the selection of apparatus. Great care ought to be taken with all flat, bolted, contact surfaces, and they ought to be designed to carry not over 100 amperes per square inch of contact. Thread contacts, however, may carry as high as 200 amperes per square inch of cylindrical surface with safety.

In the previous discussion the writer has touched upon the main varieties of direct-current switchboards. There are many special arrangements met with in practice, but those described are the most common. All mention of direct-current storage-battery switchboards is omitted because they are special in nearly every case, and are supplied by the respective storage-battery companies, together with electrically operated end cell switches and testing apparatus. No mention has been made of direct, constant - current switchboards, used mainly for arc lighting, which are usually simply plugging systems.

It will be seen from the foregoing that the most important pieces of apparatus which go to make up a switchboard are the circuit breakers and switches. The switches in use to-day in the best engineering practice are made of pure Lake copper, and nearly all manufacturers have united with the National Board of Fire Underwriters in adopting standard spacings for different voltages. A single-pole knife switch can be obtained in capacities up to and including 4000 amperes; but a single-pole switch of this capacity is as large as the ordinary man can easily

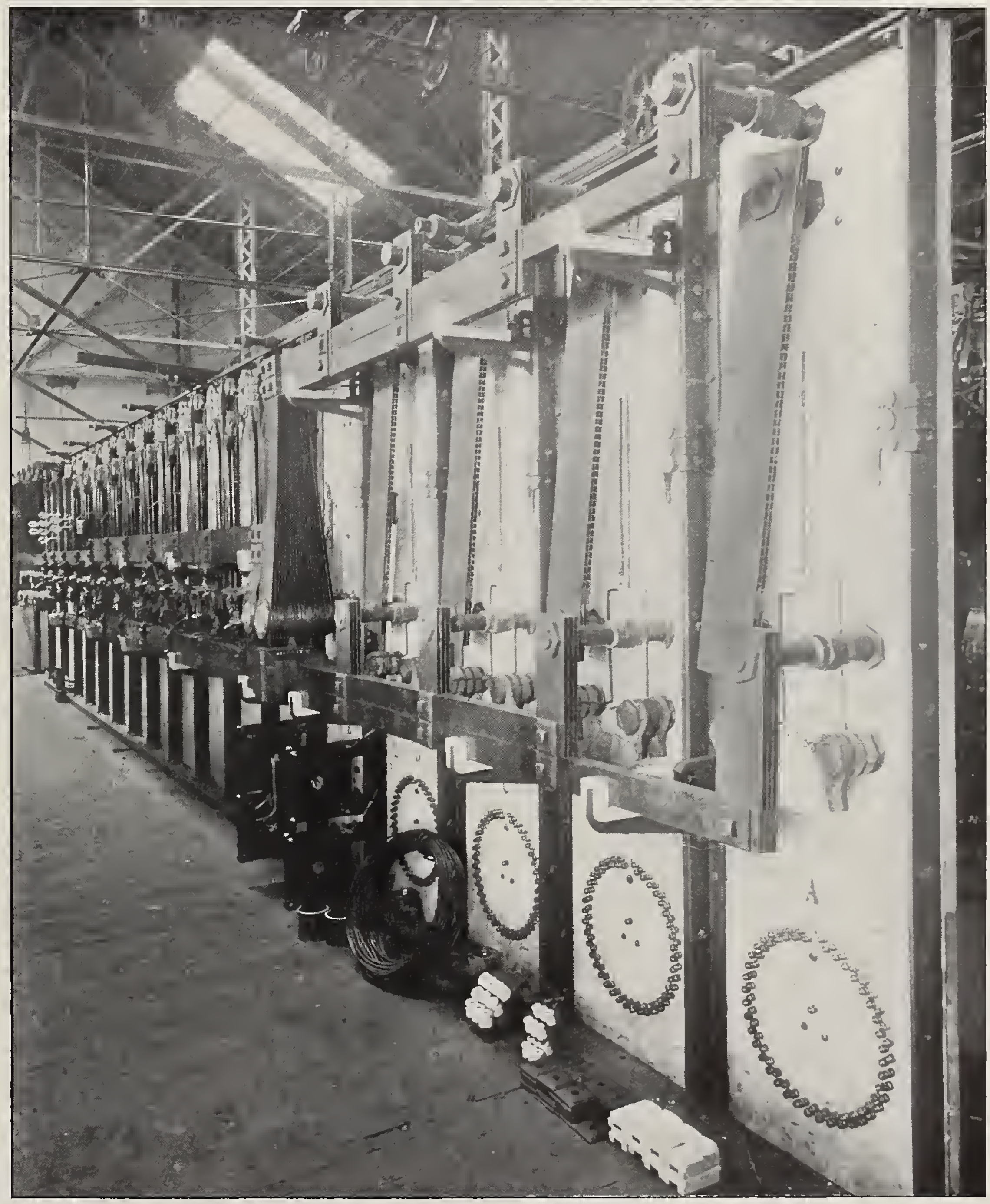


FIG. 8.—A REAR VIEW OF THE SWITCHBOARD SHOWN IN FIG. 7

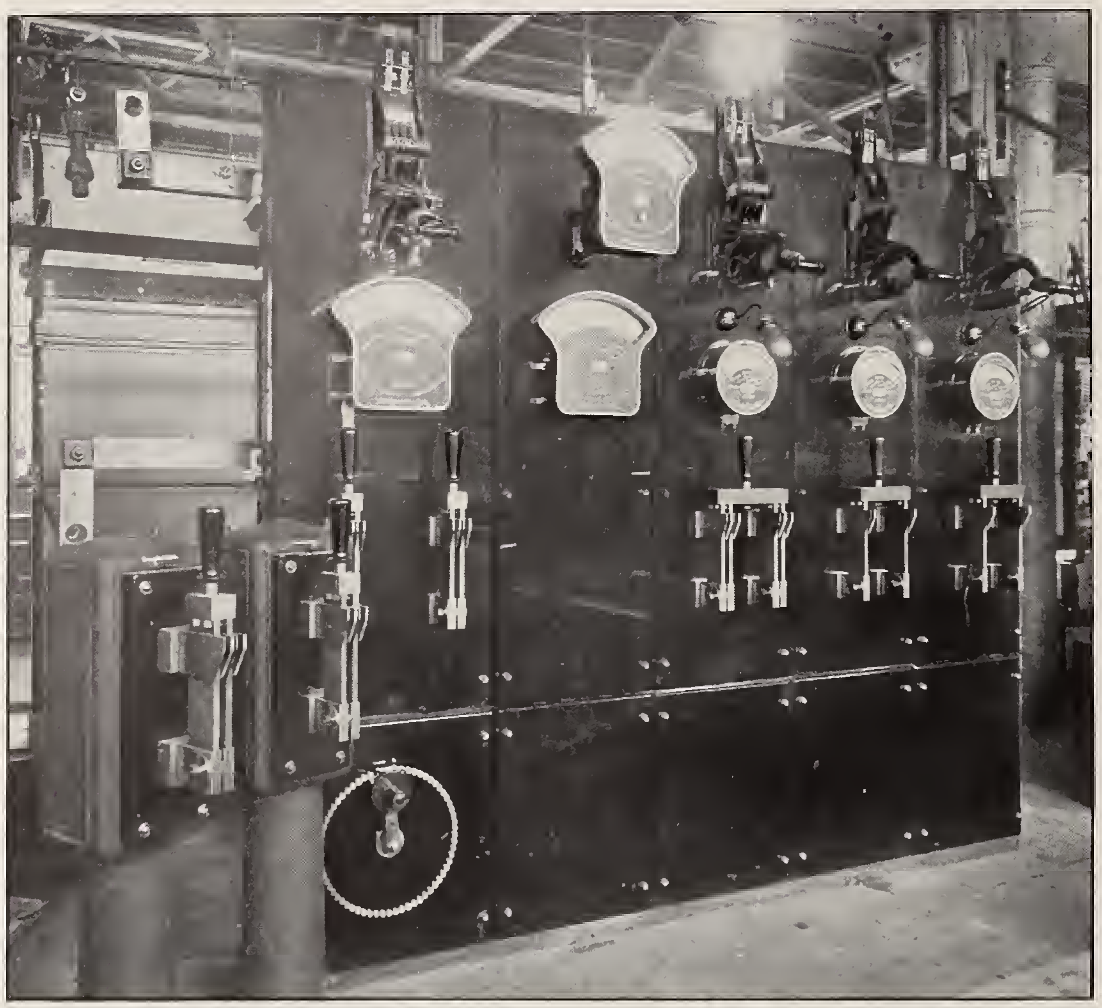


FIG. 9.—A LIGHTING AND POWER SWITCHBOARD

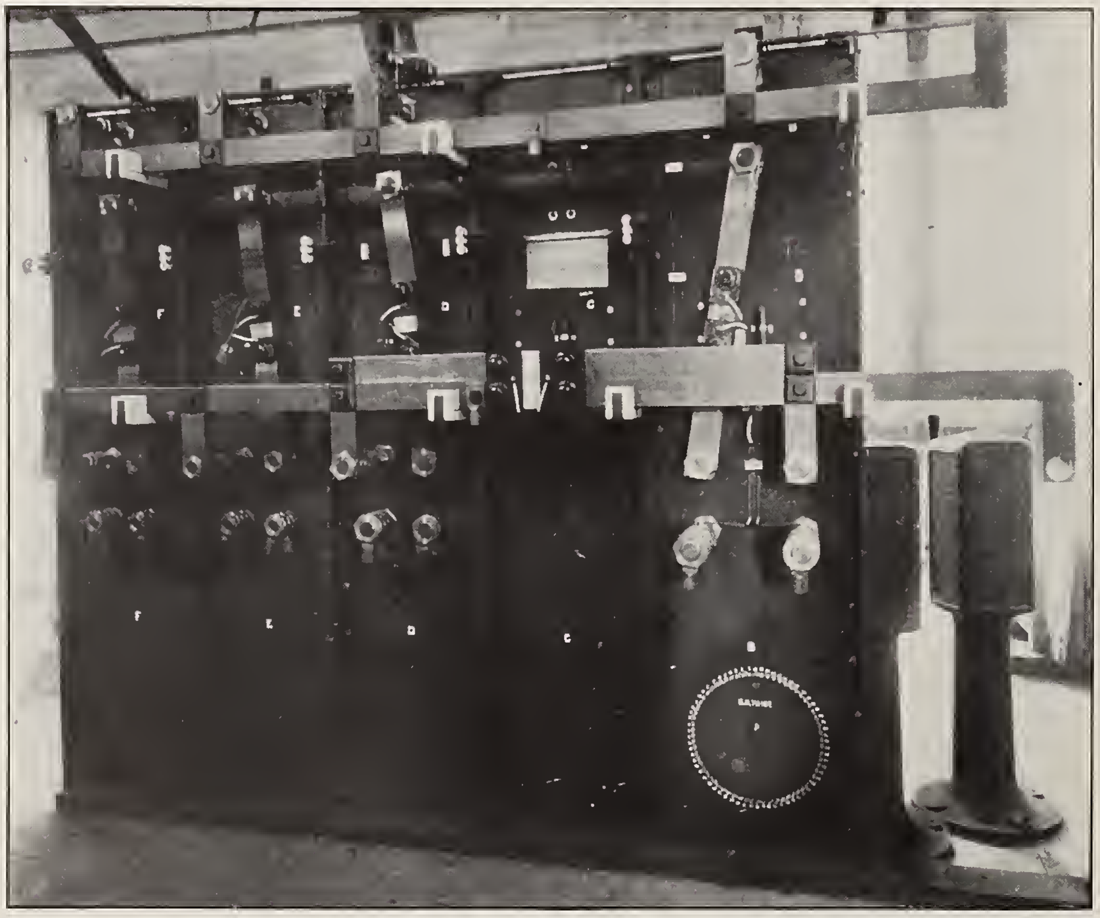


FIG. 10.—A REAR VIEW OF FIG. 9

handle with contact obtained by the spring of the jaws against the blade. For larger capacities it is common to connect two or more switches in multiple, or to operate them with a hand wheel if they are made in one switch. Two-pole switches are often made as large as 2500-ampere capacity, and three-pole switches as large as 1600-ampere.

As to circuit breakers, the carbon-break type seems to have survived all others. The original carbon-break type has been superseded by a type having a single carbon-break at the top in shunt with laminated brush contacts closed by a toggle. Some of the first of these breakers to be installed were used in the large railway power houses in Pittsburg and Allegheny. At the present time this form of breaker is used almost exclusively for heavy service. As the arc rises upward the breaker is usually mounted at the top of the panel, especially for pressures above 250 volts.

Views of a very elaborate lighting and power switchboard using the earlier form of this circuit breaker are shown in Figs. 14 and 15, which illustrate a switchboard built for the Park Row Office Building in New York City. The heavy bus-junction switches on this switchboard are operated by hand wheels. All of the apparatus was very finely finished. The recording meters were built in France and operated from shunts located on the rear of the panels. This switchboard furnishes a good example of the special design that is so often installed in large office buildings.

Switchboard engineering has become a science. Developments may be looked for at all times, and what has been described here as modern practice may soon be old electrical history.

A German School for Employees of Electric Plants

A FEW months ago the Central Trades Association of Konigsberg, Prussia, instituted a free course of instruction for those who are employed at the electrical works in that city (minors excepted). The lectures, which are held two evenings a week from 7:30 to 9:30, are delivered by some expert engineer, who has had long practical experience. At the end of each course, which lasts about twelve weeks, examinations are held. Those who succeed in passing these examinations are awarded certificates which set forth the fact that they have performed their work in a satisfactory manner.

The Canadian Grand Trunk Railway will substitute electricity for steam in the Sarnia tunnel, connecting Sarnia, Canada and Port Huron, Mich., and will install a plant for that purpose to cost $500,000. The third-rail system will be used.

The Chicago Telephone Supply Company has made an offer to install a municipal telephone system at Brantford, Ontario, for $37,500. It is proposed to supply the present customers of the Bell Company with 'phones free of charge until their existing contracts expire.

Cable Laying and Telegraph Line Construction in Alaska

By GEORGE E. WALSH

PRIOR to the Spanish-American war, the United States, although possessing the greatest extent of ocean and lake coast, had the smallest mileage of telegraph cables owned and operated by any of the great powers. There was not a single cable-ship or any grappling apparatus owned by the United States, and the United States Signal Corps had no experience whatever in cable-laying beyond such theoretical work as that obtained in the Naval Academy.

If no other direct benefit should accrue to the United States in taking possession of the Philippine Islands than the stimulus to the art of cable-laying and manufacturing, this alone will be of great value, for it may be said that recent cable-laying by Americans was due entirely to the necessity imposed upon them by the war. In order to prosecute the war successfully, cable-cutting and cable-laying had to be attempted at once. The first cableship of recent times owned by the United States was the Spanish merchant ship "Rita," captured by the converted cruiser "Yale." This ship was immediately remodeled as a cableship, and succeeded in splicing several cables off the coast of Cuba and in laying new lengths to keep the Army and Navy in touch with each other.

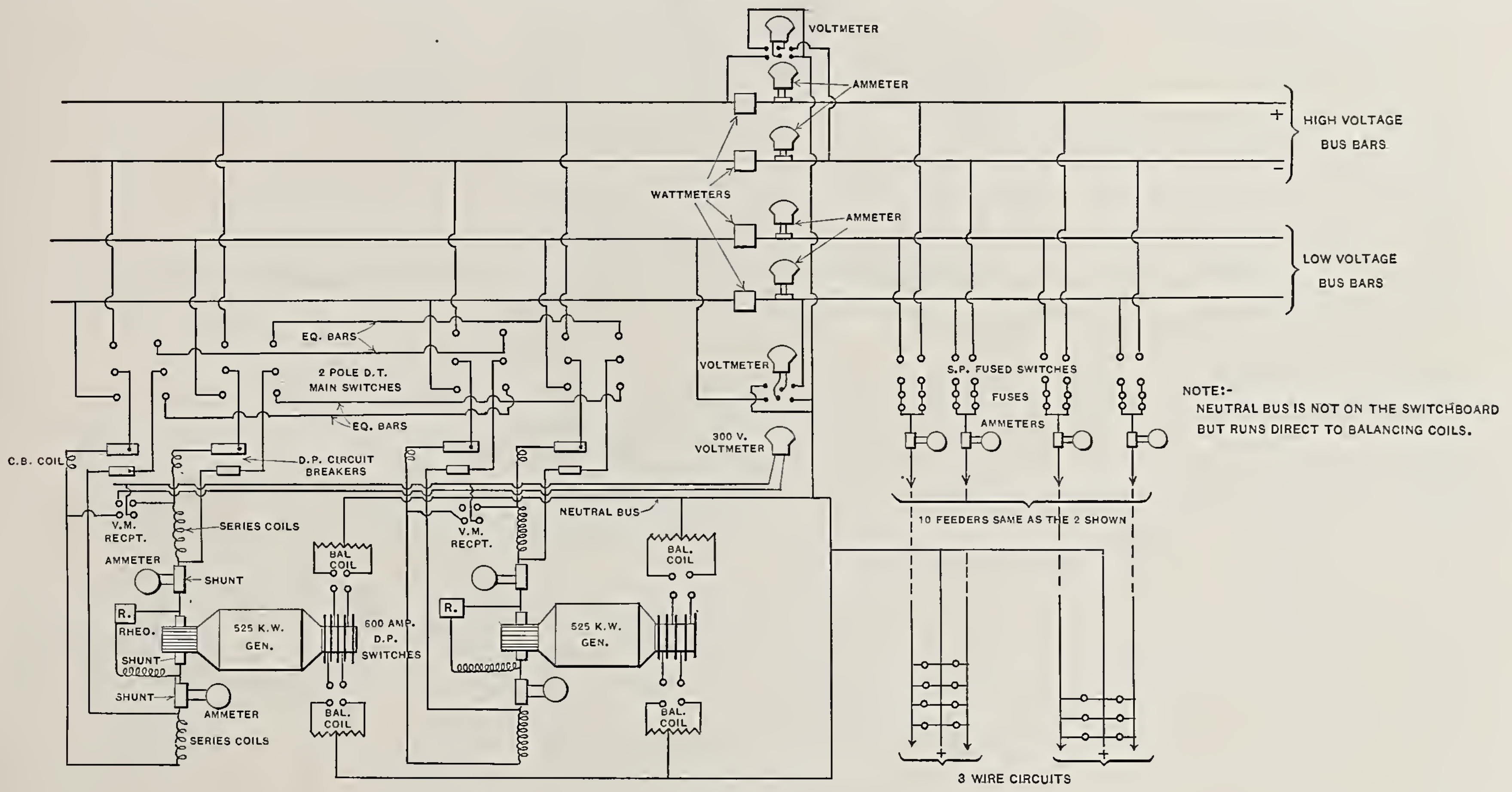
From this small beginning, cable-laying progressed, until to-day the United States stand among the foremost nations in this field. The Army and Navy, upon taking possession of the Philippine Islands, immediately proceeded to establish telegraph and cable lines along the coast. This work was doubly difficult, owing to the lack of experience of the officers and the absence of adequate apparatus. Nevertheless, the best possible use of existing conditions was made. The Navy exerted itself to lay cables along the coast about Manila, and soon made a new record in this field Torpedo boats, small wooden cruisers and gunboats were converted into cable-laying ships, and with totally inadequate material for doing effective work, the men of the Signal Corps distinguished themselves. Often the cable reels and grappling machines were improvised for the occasion by ingenious officers who realized the necessity of dealing with crude conditions in a unique way.

The Spanish converted cable-laying ship is to-day one of the most important of the prizes captured from Spain during the late war. Rechristened "Burnside," she has been working continuously in the interests of peace. Over 2000 miles of cables were laid around Manila within a few years after the conquest of the Philippines, and a large number of these cables were laid by the "Burnside." To date, this cable-laying ship has more than 1500 miles of existing cable to her credit.

Her most recent exploits have been among the ice floes and fields off the Alaskan coast. In laying the Alaskan cable, the Signal Corps men have had to cope with difficulties of an unusual nature, and their exploits in this field are as noteworthy as those along the coast of the Philippines. The "Burnside" was called upon to lay cables at some very great depths. The average depth of the water along the coast where the cable was laid is 1000 fathoms, but in rounding Vancouver Island the depth suddenly increased to 1600 fathoms, or 9,600 feet.

In order to handle a cable that is sufficiently strong to resist the strain imposed upon it when stretched over a long distance where the depth varied so greatly, the "Burnside" had to be equipped with powerful grappling and reeling machinery. This may be better appreciated when it is stated that 500 miles of the cable, which stretched from Sitka to the Straights of Juan de Fuca, weighed 1500 tons.

The laying of the Alaskan cable was merely the preliminary step in establishing complete telegraphic commu-



DIRECT-CURRENT SWITCHBOARDS

FIG. II.—THREE-WIRE SWITCHBOARD DIAGRAM FOR THE ATLANTA RAILWAY AND POWER COMPANY, ATLANTA, GA. SEE PAGE 330

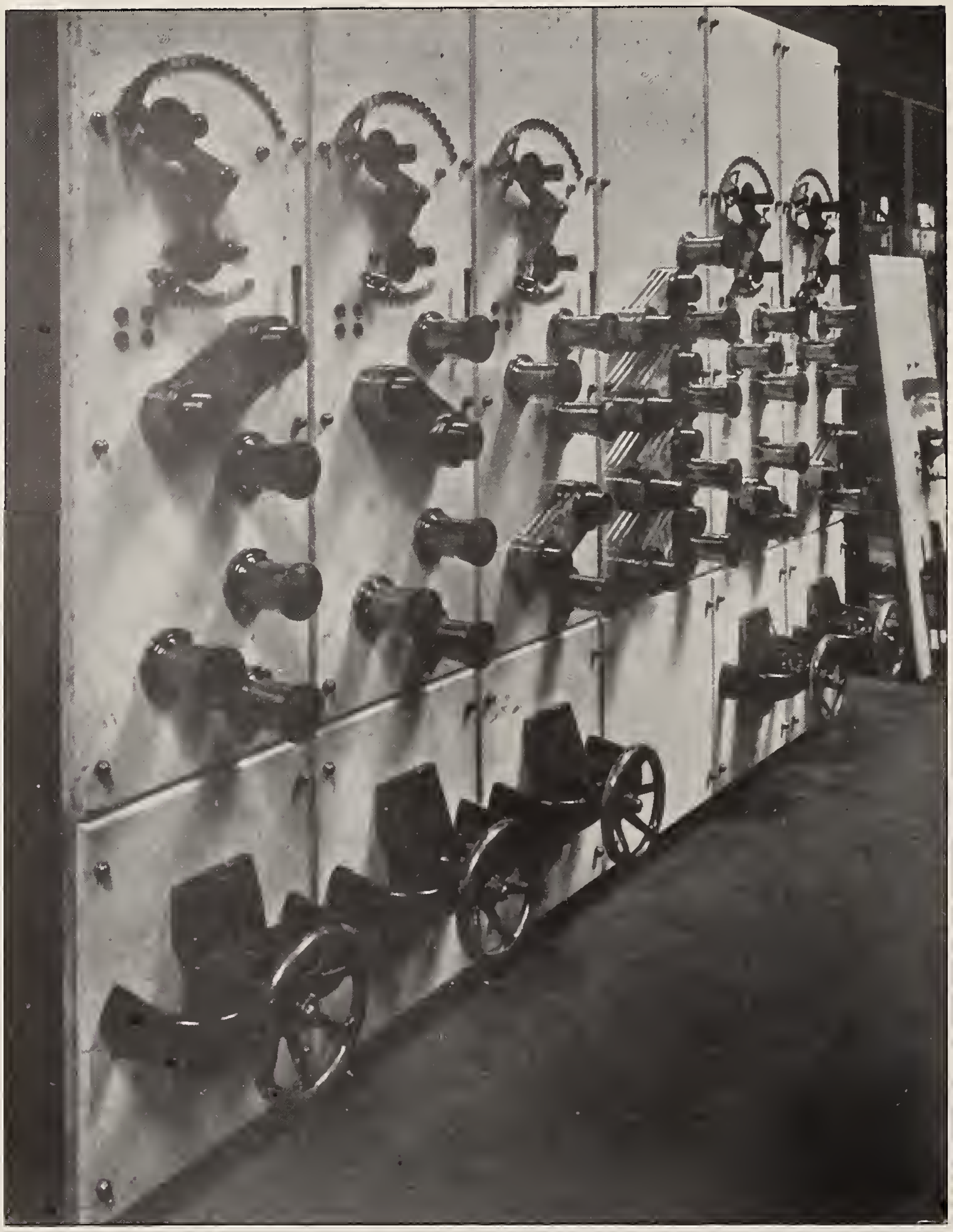


FIG. 12—A SWITCHBOARD FOR CONTROLLING ELECTROLYTIC MACHINES. SEE PAGE 331

nications with the most important places of Alaska. With the cable laid from Seattle, Wash., along the coast to Skagway at the head of Lynn Canal, and branch connections to Sitka, Juneau, Haines Mission and other towns and cities, communication with Cape Nome was established by way of the Canadian line across White Pass and down the Yukon River to Dawson, and thence to St. Michael. Wireless communication 115 miles across Norton Sound to Cape Nome completed the line. By laying another cable along the coast from Skagway to Valdez, an all-American line was established from the most northern city of Cape Nome to Seattle.

Work on this most northerly of great cables had to be suspended in winter time, owing to the intense cold and rough weather. Even in the summer months the difficulties were at times almost insurmountable. At a distance of several thousand miles from the base of supplies, the workmen were often interrupted for weeks and months by lack of proper material or by the breaking of machinery. When the "Burnside" steamed along the coast, unreeling the great lengths of cable, telegraphic communication was constantly kept up between the ship and the shore to make sure that there was no flaw in the cable.

Often with the sea full of ice flows and icebergs, the "Burnside" faced troubles of an unusual nature. Several times she was caught in the ice-pack so that it took a great deal of skill to free her. The cable itself dragged heavily behind at such times, and the chafing of the ice threatened to destroy the insulation. To combat these unexpected difficulties the engineers were forced to construct a temporary sheath over the stern of the ship to protect the cable when passing into deep water.

General A. W. Greely, chief of the Signal Corps, was in complete charge of the whole work of laying the cable, and his reports and personal observations indicate that the feat was one of the most remarkable on record. Besides laying the submarine cables, he had control of the work of stringing the wires inland across thousands of miles of the coldest, wildest and most barren country on the globe. It required several years to do this work, which the winters stopped completely many times and to which the short summers added new difficulties.

The transportation of the material for erecting the telegraph wires across such an impassible country demanded extraordinary sacrifices and ingenious inventions. The route lay across mountains, through valleys, up steep declivities and across many marshes, rivers and canyons. In the winter season the Signal Corps men faced fierce blizzards and freezing weather. Yet in the summer time it was impossible to cross the rolling marshy lands or "tundas" and low meadows, and the work of stringing wires across them had to be done in the middle of winter.

The men had to carry provisions, clothing and all other needful articles with them. When they cut loose from their base of supplies and faced a wild, unsettled land within the Arctic Circle, they endured many privations. At one time in constructing the line from Dawson to Valdez, a distance of over 400 miles, the men were encompassed by snow and ice so that for months they had no communication with the outside world, although this part of the route was along the regular Government trail.

In the stretch down the Tanana River, a tributary of the Yukon, the work was done almost entirely in the winter months. It was impossible to cut through the ice and frozen ground in winter to erect poles, and in summer the place was so soft and marshy that it was impossible to carry the poles and reels across the ground. The only possible method left was to distribute the poles along the route in winter, reel out the wire and attach it and then wait to erect the poles until summer melted the ice and softened the frozen earth. This had to be done under very difficult conditions. The men often worked up to their waists in mud, water and melting ice, with their feet almost frozen and their heads overheated by the hot sun, and attacked by swarms of insect pests. In particularly soft places, the poles were reached by means of platforms built out to them. The workmen even made a rude sort of summer snow-shoe by which they could slide out across the soft marsh and support their weight.

The summer months in such iso-

lated regions of Alaska are not so delightful as on the selected Government trail on which tourists and miners travel during July and August. Up on the mountain sides, the weather and country are delightful, but down in the valleys the miasmatic conditions are intensified by vast swarms of mosquitoes and other insects. So fierce were these pests in their attacks that the men were forced to protect themselves with netting. This was shipped by the Government in large quantities both for camp purposes and for individual use.

A good many sections of this most northerly telegraph line passed through parts of the country entirely bare of any trees suitable for telegraph purposes. This made the work of the men doubly difficult, for the transportation of the long poles over miles of rough, cold country was necessarily a hard task. Dog teams, reindeer and even horses and mules were utilized. Frequently the route lay down the sides of snow-covered mountains, and the work was rapidly performed; but when sharp inclines were reached the crude transportation methods failed. The men had to haul up the poles one by one, and in some cases construct slings to pull their beasts of burden after them.

Rivers that were frozen solid in winter thawed out in early spring and washed away the poles and wires. Tremendous blizzards swept down through the mountain passes and not only drove the men to shelter, but also wrecked the work of weeks. Between Yukon and St. Michael, one of the longest stretches through a wild country, a distance of 800 miles, storms repeatedly destroyed the wires erected, and in one storm nearly 200 miles of poles and wires were thrown down. In the Tanana Valley, when the work seemed nearly completed, a fierce forest fire started in the summer, and this swept across the route and destroyed poles and wire, so that the work had to be done over again.

The use of wireless telegraphy was anticipated in the early struggles of the Signal Corps men in this wild part of the world. It was expected that great gaps in the system could be easily bridged by wireless systems, especially across rivers, sounds and wide marshy valleys. Parts of the system were therefore left unconnected; but difficulties arose. Great quantities of wireless telegraph material were shipped north, and long wooden masts for the wireless stations were shipped up the coast and transported across the rough country at great expense and trouble; but in many instances the installation proved a failure, owing to difficulties of a climatic nature. During snow storms and blizzards it was found impossible to send messages successfully through space, and these blizzards were quite frequent and often of several days' duration.

Eventually, however, the wireless systems were established so that messages could be sent. The most important of these wireless routes is across Norton Sound at Cape Nome, but several smaller stretches have been perfected along the route. Some of these are located in lonely parts of the country where the station will be kept in working condition throughout the year at considerable trouble.

The successful working of the wire lines has also been hindered by climatic conditions. In winter the wires become coated with ice and snow a foot thick, and the resulting load breaks the wires. Along some parts of the route the snow piles so high in drifts that the telegraph poles are hidden from the view, and men sent out to find the breaks in the line are for days in the drifts before they can reach the point of trouble. The intense cold, furthermore, decreases the tensile strength of the wires so that in the middle of the winter the snapping of the wires along the route is continual and annoying.

Owing to the great difficulties experienced in constructing and maintaining the telegraph lines, wireless systems that would carry messages with unfailing regularity across the wide valleys from mountain to mountain, and across rivers and marshes, would prove of the greatest service and economical value. Consequently, extensive experiments will be made in Alaska with this system. In the interior the mountain ranges interfere with wireless messages, and frequent stretches of wire must be used to cross the high passes and peaks. In the main, however, wireless telegraphy ought to prove of more value for overcoming difficulties in a country like Alaska than in the United States.

When the first experiments were tried it was found that the wireless messages sent across ordinary gaps in the route were very unsatisfactory, only the faintest impulses being received. It was surmised that this trouble was due to peculiar climatic conditions of the Arctic zone, but later it was demonstrated that the fault was either in the transmitting or in the receiving apparatus. With these troubles rectified the wireless system has steadily improved, and with a successful system in operation across the widest span at Norton Sound, the future of the work is assured.

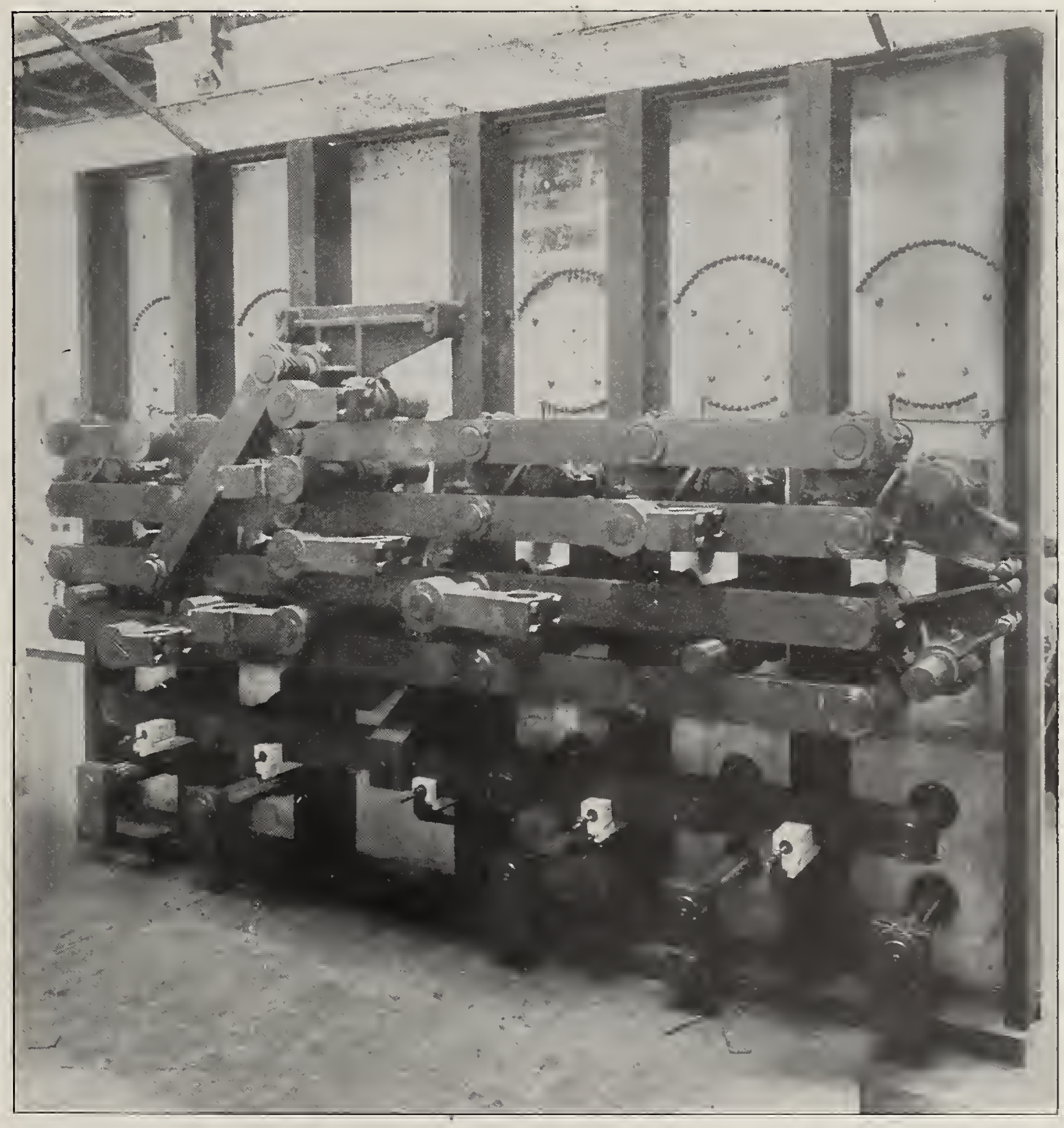


FIG. 13.—A REAR VIEW OF FIG. 12. SEE PAGE 331

The Steam Turbine in Central Station Practice

By W. L. R. EMMET

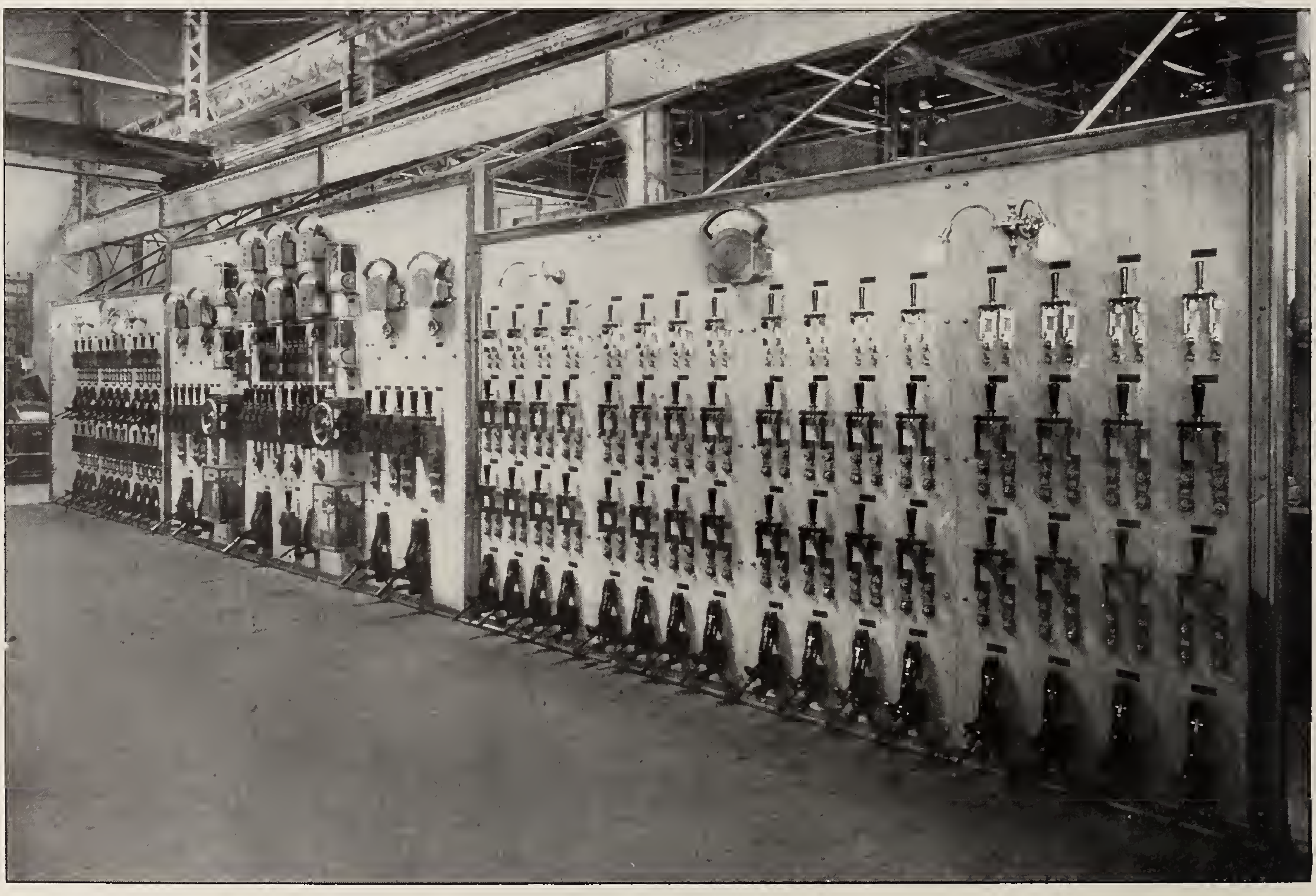
A Paper Read at the Recent International Electrical Congress at St. Louis

SINCE there are few completed steam turbine stations which can be considered thoroughly representative, and since the turbine art is new and still in a state of rapid development, it will be best in discussing the subject here selected to deal with the possibilities of the future, rather than with results actually accomplished.

Decisions concerning the relative advantages and disadvantages of turbines as compared with reciprocating engines, and concerning the methods by which the best results can be obtained from steam turbines, are of very vital importance to all engineers at present engaged in new or prospective developments. When the plans of a station are adopted, the owner necessarily commits himself to many large expenditures, and all of these expenditures should be made to conform to a system of operation which is to be followed for a considerable period of time. If central stations are designed without such definite plan, they are almost certain to involve a waste of money and to lead in a short time to new developments and reorganizations. There is probably no department of industry in which foresight is more valuable than in this matter of central station design.

Since steam turbines differ from other steam engines in many important respects, it becomes necessary to make special provisions for their use if their greatest advantages are to be made available. It consequently becomes very important for designers of power plants to decide in advance whether steam engines or steam turbines are to be used, and in deciding this question the immediate prospects of development in steam turbine design should be considered as well as the results which have up to the present time been actually achieved.

All reciprocating steam engines operate upon the same principle, namely, the pressure of expanding steam upon pistons. The degrees of economy in steam engines depend upon the perfection of the methods by which this application is made. Improvements of economy in steam



DIRECT-CURRENT SWITCHBOARDS

FIG. 14.—THE ELECTRIC LIGHTING AND POWER SWITCHBOARD IN THE PARK ROW BUILDING AT NEW YORK. A GOOD EXAMPLE OF SPECIAL DESIGN OFTEN INSTALLED IN LARGE OFFICE BUILDINGS. SEE PAGE 332

engine designing are effected by various perfections of arrangements and multiplications of parts and are limited by considerations of mechanical expediency of speed and of cost. By multiplication of cylinders high degrees of expansion are obtained without undue increase in cylinder condensation, and by special arrangement of valves clearances are reduced to a minimum, and a distribution of steam effort is arranged in the most advantageous manner. The greatest restriction of possible economy in the reciprocating engine lies in the limited range of its expansion. As steam expands to low pressures its volume naturally increases in a rapidly multiplying ratio, and this increase of volume is so great that it soon passes the limit of capacity for which cylinders can be profitably designed. There is thus a large proportion of the available energy due to expansion of the steam which cannot be used in reciprocating engines, and which must be lost in the form of heat in exhaust steam.

I have recently examined some tests of a very modern and highly efficient generating plant with large compound engines, and these tests show that only 1 per cent. of improvement was obtainable by increases of vacuum beyond 25 inches. With steam coming from boilers at 150 pounds gauge pressure, the available energy per pound expanding to a 25-inch vacuum is 213,000 foot-pounds. The available energy in expanding to a 29-inch vacuum is 272,000 footpounds, so that in this case there is 27 per cent. of the expansive force in the steam untouched by the engine under its most favorable conditions of operation. This amount of waste effective force is, however, not all that should be considered, since the engine begins to be an inefficient abstractor of energy at a much higher pressure than that of a 25-inch vacuum. The best engines open the exhaust at a pressure of 7 or 8 pounds absolute, and consequently lose a large proportion of the expansive force of steam below that point, the degree of vacuum below the point of exhaust serving only to diminish the back pressure and not implying an effective expansion to the vacuum point.

The steam turbine possesses the inherent advantage that it can be so designed as to work effectively to very high degrees of expansion in the steam. Since the steam in the turbine is not confined to chambers where it must exert pressure, it is available for doing work as long as it possesses expansive force capable of imparting an effective velocity to the steam itself. Steam turbines can thus be designed to work to the highest degrees of vacuum, and the efficiency of action at the extreme limits of expansion can be made as great as that in the initial processes where pressure is high. Thus the steam turbine operates in a larger field of theoretical possibility than does the steam engine, and if in all its processes it can be made equal to the steam engine in efficiency of action, it will give from 30 to 40 per cent. more useful work from a pound of steam.

Because this theoretical possibility exists, it must not be assumed that such a result is easily obtainable, and it is probable that many years will elapse before any large proportion of this theoretical possibility is realized. The best result in steam economy which has yet been obtained by a steam turbine in practical operation has been almost exactly equaled by highly improved modern reciprocating engines of the same size operating under similar conditions.

It may, therefore, be said, speaking generally, that the steam turbine has up to the present time simply overtaken the steam engine in the matter of steam economy, and that its other advantageous features constitute the most obvious reasons for its adoption. While these other advantages simply justify in most cases the installation of steam turbines rather than reciprocating engines, they should not alone be considered; due weight should be given to the great prospective value of the steam turbine idea and builders of central stations should not commit themselves to conditions unfavorable to steam turbines in the face of the rapid advances of the turbine art and the certainty of continually improving results.

While steam turbines have been built and experimented with for a period of twenty years, their development on a large scale for central station use has been confined to the past four years, and the advances made within the past two years have first brought the steam turbine to the serious consideration of the whole engineering world. The work which has so far been done upon steam turbines has been much restricted by manufacturing considerations and by the absence of the most essential experimental data. The process of experimenting with steam turbines is peculiarly difficult, and their action is such that nothing but experimenting can bring about an ideal system of design.

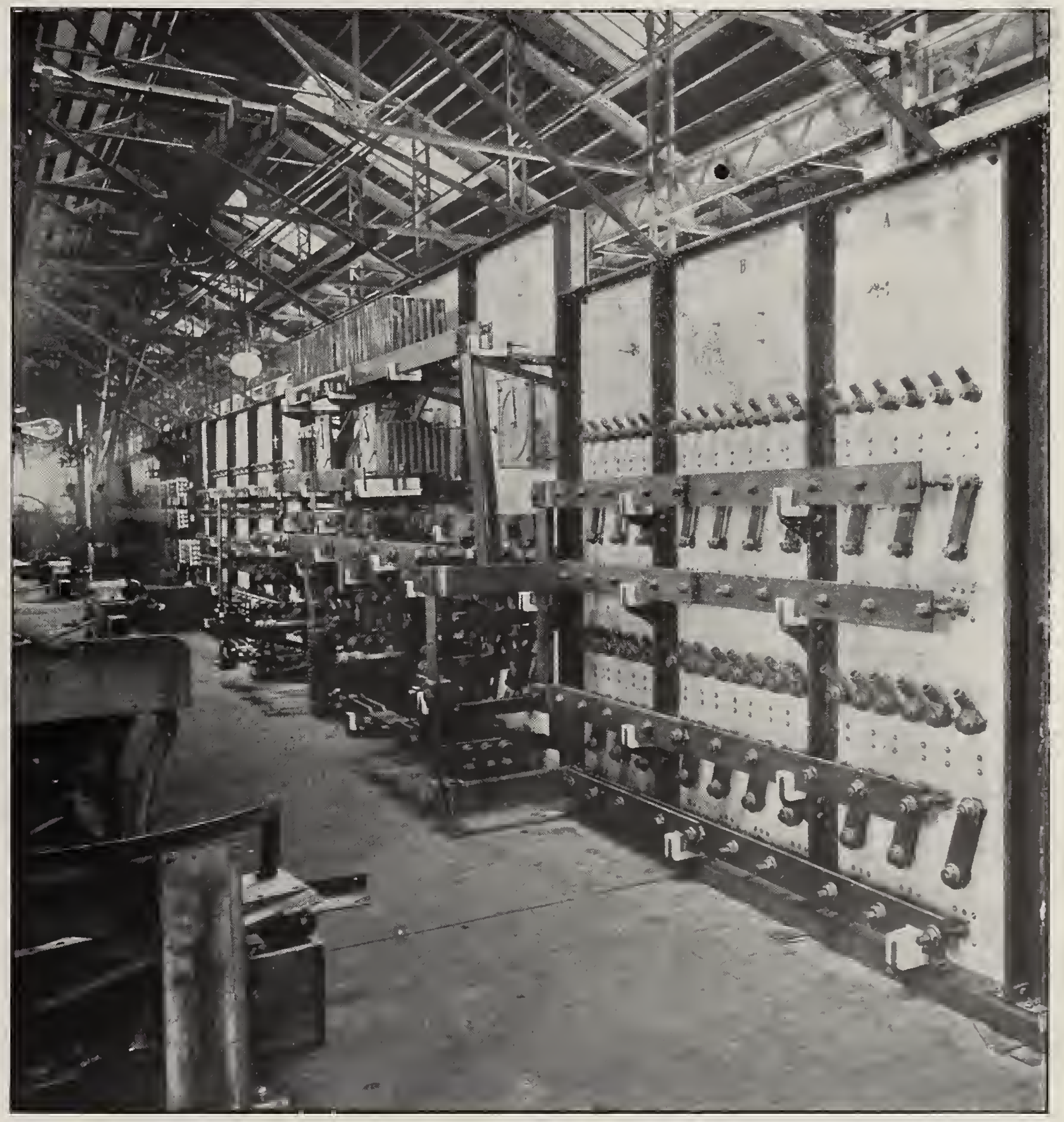
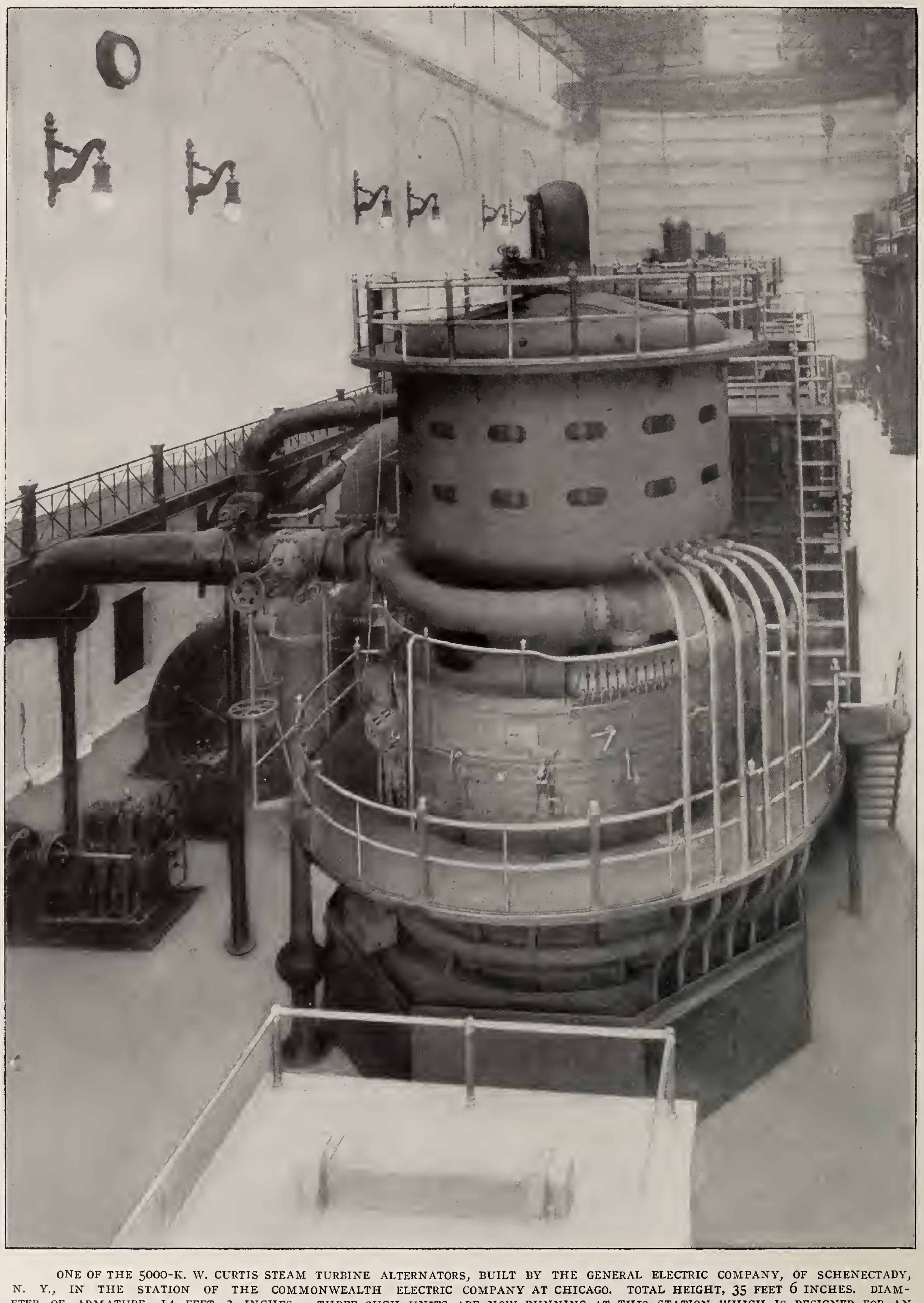


FIG. 15.—A REAR VIEW OF THE PARK ROW BUILDING SWITCHBOARD. SEE PAGE 332



ONE OF THE 5000-K. W. CURTIS STEAM TURBINE ALTERNATORS, BUILT BY THE GENERAL ELECTRIC COMPANY, OF SCHENECTADY, N. Y., IN THE STATION OF THE COMMONWEALTH ELECTRIC COMPANY AT CHICAGO. TOTAL HEIGHT, 35 FEET 6 INCHES. DIAMETER OF ARMATURE, 14 FEET 3 INCHES. THREE SUCH UNITS ARE NOW RUNNING AT THIS STATION WHICH IS DESIGNED FOR AN ULTIMATE CAPACITY OF 60,000 K. W.

Many engineers may consider that the part of conservative wisdom is to adopt only apparatus of which the usefulness and the reliability have been well established by experience. There are many cases, however, in which such reasoning cannot be wisely adopted, and the case of steam turbines is probably the most conspicuous among these.

Apart from its possible efficiency, the principal advantages of the steam turbine are simplicity, moderate cost, low cost of maintenance, economy of space, economy in foundations, absence of oil in condensed water, minimum labor and skill required in attendance, possibility of installation on any kind of ground or on the upper floors of buildings, perfect speed control, absence of pulsations in speed, absence of expense for lubricants, diminished danger through possible destructive speeds, and large overload capacity.

The degree of these advantages is naturally hard to judge in the present state of the turbine development, and is undoubtedly very different in different turbines now operating. The most improved turbines which have been produced attain all of these advantages in such a degree as to give heavy weight to the balance of judgment as to whether reciprocating engines shall or shall not be used in new installations.

In the cases of certain large central stations which have come to my notice, the adoption of turbines has effected a saving of about 5 per cent. in the cost of buildings alone through the adoption of turbines instead of reciprocating engines whose steam economy was assumed to be the same. This saving does not include the saving in foundations necessary to support the engines themselves, and does not consider the economies accomplished through the fact that a station for steam turbines can be put on almost any kind of land without unreasonable expense for foundations. Any surface which will satisfactorily support a battery of boilers can, at trifling expense, be made to carry the steam turbine which they will supply, whereas in the case of reciprocating engines heavy expenses for foundations are in many cases necessary.

Another of the advantages mentioned, which is of great practical importance, is the absence of oil in condensed water. The condensed steam from almost all of the turbines which have been installed by the General Electric Company is being returned directly to boilers, and this re-use of condensed steam in many cases effects a large saving either in bills for feed water, or in the expense of maintenance and cleaning of boilers.

In connection with this it may be desirable to consider the possible corrosion of boilers through use of such condensed water. The ideas which prevail upon this subject seem to be various and inconsistent. It is generally considered by practical steam men that water of condensation causes rusting of boilers, and there is no doubt that under certain conditions it does so. The fact seems to be that pure distilled water with air in solution attacks iron very rapidly, and that a small percentage of impurities of certain kinds will neutralize the free oxygen in solution and prevent corrosion.

In naval vessels, where distilled water is constantly used in boilers, injurious corrosion is prevented or limited by the use of a certain amount of fresh water obtained from shore, which, I am told, accomplished the desired purpose. Rusting of boilers must come from free oxygen in solution, and it is certain that this oxygen can easily be neutralized and that all trouble from its presence can be avoided. It is also probable that there will be no appreciable rusting of boilers where the conditions are such as to prevent the introduction of air with feed water. Where dry air pumps with high vacuum are used with surface condensers, it is probable that the feed water will enter boilers almost entirely free from oxygen in solution, and that no rusting will be observed. While I have heard many expressions of fear concerning trouble from this cause, I have not as yet heard of any such trouble in connection with a turbine installation.

When a consideration of the above mentioned conditions has led to the adoption of turbines in any installation, the plant should be so designed as to accomplish the greatest advantages from their use, and the matter of first importance is to procure a good vacuum. In steam turbines of the most improved design impairment of vacuum through leakage of air can be almost entirely prevented. The packing, where the shaft passes through the shell of the turbine, can be sealed with steam in such a manner that leakage of air will be impossible, and all the joints below the atmospheric pressure can easily be made perfectly tight, since their temperature is not excessive, and since the simple application of heavy paint to the exterior will generally accomplish the purpose even where joints are not perfectly made.

In reciprocating engines the value of high vacuum is not very great, and, consequently, great efforts have not been made to attain it. Considerable leakages of air occur at various points about engines and exhaust connections, and the designs of pumps and condensers used have in many cases not been adapted to the production of high vacuum. Thus, engineers experienced in steam engine work have become accustomed to degrees of vacuum which are too low for the best results of turbines, and such men generally consider that the production of a vacuum of 26 or 27 inches shows a good normal operation condition.

In the introduction of turbines the advantages of high vacuum have been considered, and special efforts have been made in that direction. As a result of these efforts very high degrees of vacuum are being continually maintained at present in many turbine installations. In one installation, where sea water is used for cooling, a vacuum within one-half pound of zero pressure is obtained. In another case a vacuum within 1 pound of zero is being obtained with circulating water constantly above 80 degrees.

In another case a corrected vacuum of 28 inches is being almost constantly maintained with a cooling tower and wet air pump. In the Chicago Edison Company's installation a vacuum within 0.6 pounds of zero pressure is being maintained with circulating water from the Chicago River. These, and many other cases, show that high degrees of vacuum are commercially attainable with turbines, and the advantages of such vacuum should be duly considered when installations are designed.

The trouble sometimes experienced in getting a good vacuum with reciprocating engines leads many engineers to magnify the difficulty of this matter. Experience has proved that under common conditions, high vacuum need not involve any great expense. In a certain installation now operating, a turbine, tested a few days ago, delivered 1000 H. P. exhausting into a surface condenser with 2700 square feet of cooling surface; the temperature of circulating water was 78 degrees, and its volume was fifty times that of the condensed steam; the vacuum was 27.8 inches, the temperature of condensed water being only 7 degrees below the theoretical temperature corresponding to the vacuum pressure. While in this and other cases a good vacuum is obtained with condensers of moderate size, and a moderate supply of circulating water, it will generally be economical to use larger condensers with a very ample supply of circulating water, and very perfect air-pumping facilities.

In steam engine installations the advantages of condensation are often considered insufficient to warrant the

installation of cooling towers where condensing water is not available. The much greater value of vacuum in turbines will, however, make it worth while to install cooling towers in almost all such cases, even where exhaust steam may be used for heating during a large part of the year.

Another matter of importance in the design of turbine stations is that of superheat. The most improved and best turbines show large improvement in economy with superheating, and while the cost of producing superheat is a matter much in dispute, it has been fully proved that superheat is very advantageous from an economic standpoint. The most improved turbines are adapted to use with high degrees of superheat, and the use of superheat with them is not accompanied by the difficulties or inconveniences which may be occasioned in reciprocating engines.

Since, as has been stated, the best steam turbines so far developed give degrees of economy about equal to those of the best steam engines, and since the turbine, as explained, works in a larger field of available energy, it may naturally be inferred that the steam engine within its own range of action is more efficient than the steam turbine, and this to a certain extent is true. This fact naturally suggests a combination which undoubtedly has a large field of application, namely, the use of low-pressure steam turbines taking exhaust steam from existing reciprocating engines. It is probable that such combinations will be only a phase of the steam turbine development, since it is highly probable that efficiencies as high as the best steam engine efficiencies will soon be attained by turbines under all ranges of pressure, and that it will become desirable for many economic reasons to discard reciprocating engines altogether.

The most advantageous conditions for the combined use of reciprocating engines and steam turbines will be found in existing steam plants where reciprocating engines are used to operate electric generators separately or in parallel. In such plants low-pressure steam turbines can be installed and can be arranged to take steam directly from the exhaust pipe of engines without valves or governing mechanisms. The turbines would be designed to give a very high efficiency with highly expanded steam, and a condensing plant should be installed adapted to the highest degrees of vacuum. The low-pressure valve stems and rod packings of the engines should be sealed with steam, and other provisions should be made for the exclusion of air. The steam turbine should operate a generator adapted to connection in parallel with that driven by the engine. A turbine designed for operation under these conditions would be an ideally simple affair, and its maintenance and care would add little or nothing to the cost of station operation. There are many large stations in which the introduction of such turbines with proper condensing facilities would increase the output as much as 30 per cent. without any increase of the fuel consumption or change in the boiler plant.

There are probably very few stations operated with reciprocating engines where the introduction in this manner of properly designed turbines would not increase the output as much as 20 per cent. In one case recently considered 15 per cent could be added to the output of the station without diminishing at all the work now being done by the engines; that is, such an amount of work could be obtained with degrees of vacuum entirely below those from which the engines are capable of deriving any benefit.

In such cases it would generally be desirable to so design the turbine that under full load conditions it would take steam at a pressure of about 8 pounds, absolute, corresponding approximately to the exhaust point in the low-pressure cylinder of the engine. The engine would then handle all the power which it could handle with maximum efficiency, and its own output would be only slightly reduced. The turbine would handle the power to which the engine was not well adapted. Under conditions of light load some economy might be effected by changing the cut-off conditions in the engine, but it would probably be better to leave all the conditions fixed and to allow the pressure on turbine to vary as the load changed.

Such low-pressure turbines would occupy a small space, and there are probably few existing engine plants in which room could not be provided for their installation. The cost of installing such turbines with complete condensing facilities should not exceed $60 per K. W. of capacity added to the station. This in itself is a small expenditure for an additional plant, even if we do consider the fact that the use of this additional plant does not call for any increase in fuel consumption or in steam-generating apparatus.

The following table shows the approximate increase of output which can be obtained by using a low-pressure turbine with good vacuum worked in series with a good Corliss engine, over that which could be obtained from the engine alone when used with the best vacuum. The engine considered would consume with atmospheric exhaust 18 pounds per I. H. P., and with a vacuum of 27 inches or better, 27.7 pounds per I. H. P. In the turbine an efficiency is assumed, which is justified by actual experiments, and which can easily be obtained in a very simple machine of the kind.

Pressure of steam between engine and turbine in inches of vacuum	Per cent gain over output of engine when worked with high vacuum. The turbine exhausting to a vacuum of 28.5 ins.
0	26.1
4	26.5
8	26.8
12	26.3
16	25.3
20	23.6
24	20.

These figures show an important possibility which should be realized in many exciting plants; and they also illustrate forcibly the value of good vacuum in turbine work, since it shows the large amount of work actually available in these low-pressure ranges by the use of turbines.

Another application of the steam turbine, which promises considerable degrees of economy, is its use as a means of applying the waste heat from gas engine installations. The best gas engines turn about 20 per cent. of the heat from fuel into useful work, the remainder is lost either in the exhaust gases or in the heating of water used to jacket the cylinders and other parts. It should be possible to deliver the exhaust gases through the tubes of low-pressure boilers fed by water which had passed through the jackets of engines. Such boilers could be maintained with a minimum expense, and could deliver steam to simple low-pressure turbines which, with suitable condensers, would deliver a very considerable amount of power. With conservative assumptions concerning the efficiency in applying the heat to water, it can be calculated that 30 per cent. could be added in this manner to the power delivered by gas engines.

In operating efficiently at low pressures the steam turbine opens a new field of usefulness which has been practically untouched by existing prime movers, and this advantage constitutes one of the important reasons for its existence. There is, however, another consideration which will play a still more important part in promoting its uses. This advantage is its simplicity. Existing turbines in many cases have given trouble, and an examination of many existing plants might show no improvement in maintenance and attendance expense, compared with engine installations. Such a condition is, however, only temporary, and incident to the newness of the turbine work. Lack of experience in designers and timidity about new ap-

paratus in operating men have in some cases led to annoying difficulties which have caused expense and interruption of service.

There are, however, already many turbines operating practically without maintenance expense, and with extremely small labor or attendance, and the time is rapidly approaching when the steam turbine installation, exclusive of the steam-producing apparatus, will be as simple in operation as the simplest water-wheel plant. In fact there are many difficulties in water turbine operation which are absent in steam turbine work, such as the troubles from ice and foreign matter in water, and difficulties through variations of head and difficulties in governing occasioned by inertia of the moving fluid.

In Los Angeles, Cal., a 2000-K. W. turbine, built by the General Electric Company, is operated daily in parallel with several water-power plants situated at various distant points. It is handled exactly as the water wheels are handled, being kept in parallel with them under all conditions and used to supply power whenever the water wheels fail to produce it at the desired instant. This turbine is known by the attendants as a hot-water wheel, and has many advantages for this service over reciprocating engines previously used.

Electric Railways in Europe

According to "The Electrical Review," of London, the electric railway experiments on the Berlin suburban line between Niederschoneweide and Spindlersfeld, which have been in progress for a long time past, eventually induced the Prussian State Railway authorities to make a trial for a period of one year of the system in operation, with a view to determining its applicability to railway working, and possibly in regard to the metropolitan railway in Berlin.

As a consequence, the equipment supplied by the Union Elektricitäts Gesellschaft, which initiated the tests, was transfered to the State Railway authorities on July 4. The railway is an experimental demonstration of the single-phase alternating current system, and its length slightly exceeds $2\frac{1}{2}$ miles. The rolling stock comprises two motor cars and three trailers, and a train is composed either of a single motor car or of any combination formed of the five cars, in accordance with the requirements of the traffic. Each motor car is capable of accommodating forty-nine passengers, and each trailer fifty persons, so that the full complement of the five cars representing the entire rolling stock is 248 persons.

These cars are quite adequate for dealing with the passenger traffic on this short line with its daily service of twenty-four trains in either direction. The single-phase motors with which each motor car is equipped are supplied with current from an overhead wire by means of small, bow-shaped sliding collectors, and the return is formed by the track rails. The current is furnished to the motors at a pressure of 6000 volts, and is obtained from the Ober-Spree power station. A slight fault developed in one of the motor cars early in August, but this was remedied by the next day, and the service has been maintained continuously since that time.

It is reported that progress is being made with the preliminary works and surveys which have been undertaken with a view to the introduction of electric traction on the Berlin metropolitan and circle railways. The experiments which have been made with electric trains in the German capital, notably on the Berlin-Lichterfeld line, have proved to be encouraging both from a technical and financial standpoint.

The third-rail, continuous-current system is employed on the particular line in question. In some quarters the opinion is entertained that the single-phase method, as tested on the Niederschoneweide-Spindlersfeld Railway, will be selected for use on the Berlin railways. The latter and the suburban lines comprise a total length of 362 miles contained within a radius of 18 miles from the center of the city.

The question of establishing municipal electric railways of the underground type continues to engage attention in Berlin. A general plan of a proposed network of such lines has been prepared and has been approved by the Traffic Deputation, which is a committee of the Town Council. The deputation has also sanctioned a scheme for a north to south railway, which was originally suggested by the Underground Railway Construction Company. As recently modified, the project proposes the construction of a railway 5 miles in length at an expenditure of £2,450,000. In addition to this, the Siemens & Halske Company is engaged on the preparation of a scheme and estimate of cost for the construction of a high level and underground line in the western suburbs.

It is understood that the Swiss Federal Council has under consideration the question of introducing electric traction on the State railways. A conference on the subject has already taken place between Government officials and representatives of the principal electrical engineering works, but the result of the deliberations has not yet been disclosed. In the meantime, it is stated that all difficulties have now been overcome which prevented the reconstruction of the State line between Seebach and Wettingen for electric traction. The work will soon be commenced with a view to its completion at an early date.

It is reported from Brussels that a syndicate has been formed with a capital of £800,000 for the purpose of financing the building of electric railways in Switzerland and Italy. Any practical action has, however, been postponed, owing to the war and the incidental difficulties of raising capital.

The Adriatic Railway Administration has now definitely taken over the entire equipment of the so-called Valtellina railway, which connects together Lecco, Colico, Sondrio and Chiavenna. The working of the railway, which was constructed by Messrs. Ganz & Company, of Buda-Pesth, has been undertaken by the Administration itself.

Since the transfer of this high-pressure, alternating-current line, a Milan correspondent of a German newspaper states that the operation of the railway and of the Milan-Callarate-Varese-Porto Ceresia Electric Railway is regarded in trade circles as being so costly that it is doubtful whether the financial results will be satisfactory. This statement can, however, scarcely be correct, in view of the comparatively long period during which the Valtellina line has been at work and the fact that the Administration has now taken the management of the railway from the contractors.

The Milan-Porto Ceresio Railway is worked on the third-rail system with direct currents, in conjunction with generators and rotary converters, on the Thomson-Houston method. It is proposed to extend the line to Lugano, this showing also that the charge of unfavorable financial results, which is unsupported by figures as to the actual revenue and expenditure, cannot be maintained.

The newly strung lines of the Mexican Federal telegraph system aggregate 900 miles.

Electric High-Tension Line Construction and Operation

A Review of American Practice

By DR. F. A. C. PERRINE

Dr. Perrine's admirable résumé of American high-tension practice was originally presented before the recent International Electrical Congress, held at St. Louis. It was, however, specially revised by the author for publication here, and new matter also was added.—The Editor.

A CHARACTERISTIC of American practice is that it tends toward standards not only in the matter of sizes, speeds and appearance of units, but also in the methods of producing results and in types of engineering. While it may be true that this tendency was originally based upon a desire for cheap manufacture and interchangeability of parts, the present elaboration of this policy is somewhat due to the fact that in so large a country the ideas of the best men cannot be directly applied except as they may be adopted for standards.

No one section of the country necessarily produces the best men, nor does any one group of engineers dominate practice. On the contrary, the meetings of American engineering societies have taken the character of sittings of committees, at which are presented many plans, all of which are carefully discussed and sifted. From those presented the best is chosen and becomes the standard.

Accepting these results as the standard does not imply that there is general in this country a spirit of copying or of servile imitation among the engineers. On the contrary, we feel that the result of the attitude of establishing standards, so prevalent in American engineering at the present time, has introduced a wise spirit of conservatism, and has thrown the burden of proof upon each one presenting a new idea.

At the same time it has resulted in raising the character of the average engineering work throughout the country, until to-day good American engineering can be found, not only in the great spectacular plants near enough to the large centers of progress to have the personal attention of the most experienced engineers, but also in the plants in the out-of-the-way deserts or mountain regions, where the local engineer of good capacity, knowing his conditions thoroughly, has relied upon the standards established by his fellows in those particulars where his own experience has been limited. In consequence a plant is produced, not only more perfectly adapted to the particular circumstances of its surroundings, but also in all details more thoroughly satisfactory than could have been designed under any other system.

Our rule is that invariably one ought to adhere to well-established practice and introduce such modifications as are made necessary by the local conditions. This does not limit the full employment of the energies and brains of the local engineer, since, without a special consideration of outside details, there is always in every transmission plant particular circumstances which tax the ingenuity of the best. That this is the general method of American practice will be seen by any one who consults the report of the standardizing committee of the American Institute of Electrical Engineers. The report covers, not only units, standard methods of testing, and details of manufacture, but also procedure, both outdoor and in, for all types of plants. This report in itself has resulted in a certain similarity of type where problems to be solved are similar.

The work of the transmission engineer lies in fields so essentially dissimilar that even in spite of this general tendency it may be difficult at first view to ascertain what is the American practice in work of this class. On closer examination, however, one finds this work falling into natural groups dependent on the length of transmission and the voltage employed, though what has been done has been materially modified by the date of erection, since during the past ten years modifications in the arts have been necessarily reflected in the types of construction.

The general groups have been somewhat decided by the manufacturers of machinery, who have presented as preferable certain available voltages. Above 2400 volts, where transmission proper really begins, the first voltage now commonly employed is 6600, which figure has been established as standard by the needs of the lighting plants in the great cities, and has been adopted by the transmission companies in place of either a higher or lower voltage mainly because it is standard. For this voltage direct generation at high pressure is almost invariably used.

The next higher voltage now commonly employed, and practically the first one for which step-up transformers are used, is 15,000. During the past few years this has taken the place of transmissions at 10,000, 12,000 and 13,000, and it is to-day the established voltage for high-tension electric railways, the general reason for its establishment as a standard being that this voltage is not more difficult to handle, as regards insulation or switching, than the three last-mentioned lower voltages, and, furthermore, that, where the lower voltages have been previously established, the sphere of operation of the transmission plant has been found to be rather too much limited.

There are in the Rocky Mountain region and West a great number of the older plants operating at 10,000 volts, and whenever direct high-voltage generation has been attempted, voltages of from 12,000 to 13,000 volts are used. At the same time, however, the majority of the plants which have used these lower pressures in the past have circuits to-day with special transformers operating at the higher figure.

The next step is to 25,000 volts, which is the highest figure reached without special study of insulators, switches and lightning arresters. This voltage has been successfully handled without serious trouble during the past six years. A voltage of 33,000 is employed in a number of plants built about five years ago, and at this figure the special difficulties

due to line capacity, insulator size, erratic lightning arrester effects and switching begin to make themselves seriously felt. Above 33,000 volts the standard voltage is called 60,000, although in all plants that have heretofore been established to operate at this pressure, there have been installed transformers arranged for connection to various voltages of from 40,000 up to 60,000 volts. The majority of these plants are to-day operating at about 50,000 volts, some of them being unable to operate at the highest pressure on account of the character of the line insulators originally installed.

In the choice of voltage for any transmission, it is considered the best practice to establish it at the rate of 1000 volts per mile, provided the length of transmission be not above 60 miles, since above 60,000 volts no commercial work has been regularly attempted. In a table recently presented by the transmission committee of the American Institute of Electrical Engineers, the highest average voltage per mile for any one class in their report is 840; but in examining this table it must be remembered that their correspondents have reported the total length of line in service, so that, if a plant be operating two lines, 15 miles each in length, at 15,000 volts, the table would indicate an operation at 500 volts per mile, although for each line the transmission was at 1000 volts per mile.

The common lighting frequencies of 125 and 133 have for transmission lines given place entirely to the frequencies of 60, 40, 30 and 25, no use having been made in this country of the frequency of 100, and only in one locality has there been any employment of 50 periods.

In the transformation from one frequency to another, which is found often to be advantageous, simple apparatus would be employed if the frequencies in use were multiples of one another and use made of 25, 50 and 100, or of 30, 60 and 120; but, unfortunately, the four frequencies mentioned have been practically used and are to-day too thoroughly established for further change.

Systems in which lighting is the principle element, and where distribution over a wide territory makes the work of small communities an important element to the business office, employ a frequency of 60 periods per second, and at this frequency large amounts of energy are transmitted to considerable distances at the highest voltages. The frequency of 40 is largely confined to transmissions from which cotton mills are operated, this having resulted in motor speeds suitable to their line shafting.

For a number of years the two frequencies of 30 and 25 have contested for supremacy in plants primarily established for power purposes and for the operation of rotary converters, but largely on account of the very great amount of machinery installed at Niagara and employing a frequency of 25 the latter is becoming more and more to be the established standard for power purposes and seems likely to displace altogether the higher, which has no distinct superiority except that it is one-half the standard frequency used in lighting.

In the generation of power the revolving-armature machine has almost disappeared from the new plants, and revolving field generators have become so settled in type that those produced by different manufacturers are hardly distinguishable by the casual observer. For the low-head plants using turbine wheels it is necessary to provide for a 50 per cent. increase of speed, and in the high-head plants, where impulse wheels are employed, a strength sufficient to withstand a speed increase of 100 per cent. must be allowed to provide against damage from overspeeding should the power be thrown off and the water continue to flow.

The machine fulfilling these conditions and practically adopted by all the manufacturers is characteristically a revolving field machine with the poles keyed to a cast-steel spider, the field windings being of copper strip wound upon edge, the armature being constructed of a cast-iron box girder supporting the stationary armature laminations. Almost the only departure from this type of construction for power transmission work is found in the balanced type of inductor machine, in which the field is magnetized by a central stationary field coil wound with copper strip, the armature, in two halves symmetrically arranged around the central core, being of laminations supported either by cast-iron rings connected together by cold-rolled steel bars or supported by a steel shell to which the armature laminations are keyed.

Various station voltages have been employed; but, where direct generation at 6600 or 12,000 volts has not been resorted to, the practice is setting more and more to the use of about 2300 volts, this being chosen because the lower voltages require large extra station copper, and because the higher voltages introduce unnecessary station difficulties of insulation and switching. For switching, the present type of 2300-volt oil switch has been so well developed, by reason of the great number of plants operating at this pressure, that for handling a particular amount of energy it is both cheaper and better than any 500-volt switch on the market.

For plants operating at less than 25,000 volts, the step-up transformers in use are about equally divided between the water-cooled, oil-filled types and the air-blast types. Where a good supply of water is to be readily obtained, the water-cooled, oil-filled transformers have generally been given preference, as they can be more readily adjusted for a varying flow of water at different loads. The question of the relative fire risk from the two types has been extensively discussed, and it can hardly be said that any very definite conclusion has been finally reached, though the weight of opinion seems by far to be that the fire risk is at least not increased by the use of the oil-filled transformer, and the actual risk in either type seems to be a matter largely of installation.

It is perfectly true that there have been some very serious fires, resulting in the complete destruction of power plants, where oil-filled transformers have been used, but in each case the fire has started outside of the transformers, though they themselves, by reason of being installed without reference to safety in case of fire, have furnished fuel which has augmented the conflagration. To-day the conditions of installation for safety are better understood, and it now only remains to be decided whether, in the case of a fire actually arising, the oil shall be run out and the transformer cases filled with water, or the whole transformer protected either by running an excessive amount of water through their cooling coils or by so installing them that the transformers may temporarily be submerged to within a few inches of their tops. Actual protection of transformers by running water through their cooling coils has been found to be effective in at least one serious fire.

For high-tension switching, use has been made of a long arc broken between carbon terminals, and long, inclosed fuse, a fuse drawn through a tube filled with a fine, non-conducting powder, and of oil switches. The first two types, while interrupting the circuit well, draw an arc of excessive length and produce a surging which may result in an increased potential of at least as much as 50 per cent. In consequence, these types are rapidly disappearing except in plants operating at 15,000 volts and below, where the carbon break is preferred to the inclosed fuse, though it is common to install the two in series, allowing the fuse to operate as a safety device, but not for the purpose of switching. The type of switch where a wire is drawn

through a tube filled with powder is found to operate successfully up to 40,000 volts and without serious surging on the circuit, but the powder, being blown out with great force, scatters over the entire station, and is in consequence not allowable. The oil switches mainly employed are those with the vertical break and those with the horizontal break. The vertical-break switch has the advantage that the amount of oil contained in the oil tank is relatively small, and will add to possible conflagration only a slight amount of fuel. This switch is found on severe short circuits often to blow all the oil out of the tank unless the tank is built very strongly, when it becomes necessary to insulate the plunger from the tank as it enters the switch.

The horizontal-break switch, while containing a large amount of oil, will, for the same length of break, handle about 25 per cent. more energy at any definite potential. This switch can successfully be used at 60,000 volts, and up to the present time has not been found to blow the oil from the tank. These two types of oil-switch are the standard to-day, no distinct preference being given to the horizontal switch, though the writer believes that in the future this type will be used as a standard for the highest potentials.

Transmission with two-phase connection of circuits, whether using three or four wires, has for voltages above 6600 given place entirely to transmission with a three-phase connection, though three-phase transmission with two-phase distribution, described by Mr. Scott at the International Congress of 1893, is very extensively employed.

The relative merits of the delta and star connection of the lines to the transformers are still somewhat in dispute, so much so that in plants of the highest voltage, in which several voltages are provided, certain of the lower voltages are obtained by delta connections to the transformers, while the higher voltages are to be obtained by a star connection. In general it may be stated that up to 25,000 volts the delta connection is generally preferred, principally because with this connection a ground upon one line does not necessarily result in a short circuit, and, furthermore, the service is not necessarily interrupted in the case of the failure of a single transformer.

At voltages higher than 25,000 volts the transformers for delta connection become more difficult to build and insulate. Furthermore, a single ground anywhere produces disturbances of a serious character, and in consequence the star connection with the grounded neutral is employed, advantage being taken of the fact that a grounded neutral aids in the distribution of unbalanced loads, and furthermore the rise of pressure which may occur from line discharge at the time of an open circuit, or a short circuit, are not so likely to produce serious results.

For the distribution of current through the low-tension mains, it is generally the custom to transform to 2300 volts two-phase, unless either the load is mainly one of motors or there are important motors of considerable size to be supplied at a distance of half a mile or more from the substation. In such cases three-phase, star-connected, four-wire distribution is employed, permitting the connection of distributing devices to either a 2300-volt circuit between lines and the neutral wire, or a 4000-volt delta circuit for balanced loads. This combination of circuits is found to be extremely useful where a mixed load is to be supplied at varying distances.

The high-tension lines themselves are run preferably over private right of way. Railroad rights of way were at first highly prized on account of the entire absence of trees and disturbing structures, and on account of the fact that inspection and repairs are most easily provided for; but experience with such lines has proven that, for transmissions at even as low a tension as 15,000 volts, the interference with insulation by the smoke from the locomotives, which covers the insulators, more than counterbalances all the advantages, and to-day such rights of way are more commonly shunned than sought. Where railroad locomotive smoke combined with sea fog is encountered, it becomes absolutely necessary to clean each insulator at frequent periods, even though the voltage of transmission be not more than 5000 or 10,000. Along the country road this difficulty is not apparent, but in some localities farm structures and trees interfere with the transmission, so that in general it may be said that a private right of way which the transmission company can absolutely control is much to be preferred.

In the most recent types of construction the height of the pole is limited as much as possible. While there may be some increased security from malicious disturbance in the use of high poles and a decrease of line capacity may be expected, these advantages are obtained only at the expense of stability and at an increased cost. A pole 35 feet long set 5 feet in the ground permits the safe installation of either a single three-phase line with a spread of as much as 6 feet by supporting one insulator on the top of the pole and the other two on the ends of a long cross-arm, or it may be used to support two three-phase circuits on opposite sides of the pole with a spread between wires of 3 feet by the use of two cross-arms. At the same time such a pole permits the safe installation of telephone or other signaling circuits on brackets or cross-arms at a safe distance below the power lines.

These poles should not be less than 8 inches in diameter at the top and not less than 12 inches in diameter at the ground line. Variations from these dimensions may be considered as being due to special considerations based upon the location of the lines or arrangement of the circuits. It is true that such a standard pole may only be arrived at after a consideration of the wind stresses on the particular lines, taken in conjunction with the spacing of the poles; but as the maximum pole spacing on transmission lines is about 135 feet, at average wind velocities these pole dimensions may be considered safe.

Extra strength required by variations of wind stress, due either to an increase in the number of wires or to a necessity for allowance for sleet, is more commonly taken care of by shortening the spans than by an increase in the size of the pole. In some cases where severe sleet conditions are to be encountered and the wires are large, it is the practice to install these poles at not more than 50 feet apart.

The material used for poles depends largely on the locality. In the Southeastern States chestnut is the favorite wood; along the Canadian border and through the Rocky Mountain regions cedar is employed, while square-sawed redwood is used almost exclusively on the Pacific Coast. With increase in voltages and consequent increased trouble from insulators, a demand has arisen for a pole-line construction which will permit a decrease in the number of insulators and allow an increase in the size of each. This has been accomplished by the use of galvanized-iron towers not less than 40 feet from the ground-line to the wires, and spaced about 500 feet apart. One plant in Mexico has recently successfully installed this method of construction. A second in the same country has contracted for its material, and a number of plants in the United States are contemplating its use.

The question of the life of wooden poles depends not only upon the character of the wood and its condition when cut, but also upon the local conditions of atmosphere and soil. In some places the poles which are available have no longer life than about five years and, in the extreme, wooden poles cannot be greatly depended

upon for a greater period than 15 years, though the redwood poles installed along the lines of the transcontinental railroads west of the Rocky Mountains have in many instances given a life up to 35 years, and are still said to be in good condition; but these poles are set into a soil strongly impregnated with alkali, in a country where rains are few and the air is generally dry. Nothing is known as yet of the life of the galvanized-iron tower except from windmill practice, where towers, galvanized after all punching and machining is done, are found to be in good condition after a period of ten to fifteen years.

The cross-arms in use are almost invariably made of pine without treatment other than painting. These arms are let into the pole from 1 to 2 inches, being held by bolts through the pole and arm, and when long are additionally supported by braces. Even with steel poles wooden arms are used, the general feeling being that there is less probability of the circuit being completely disabled should an insulator break and the line fall upon a wooden rather than a steel arm. At the same time an experiment in the use of wooden braces has not been found to result in any certain advantage. In consequence, flat galvanized-iron braces, established a number of years ago as standard by the telegraph and telephone companies, are now almost universally employed in the construction of transmission lines. With increase in spans and voltages the insulators are increasing in size. This condition will probably in the future demand a strength of arm greater than can be obtained by the use of wood. This problem, however, has not as yet obtained a definite solution.

For plants operating below 25,000 volts much use has been made of glass as a material for insulators. Glass has been for many years the standard insulator material in American telegraph and telephone practice, and in spite of many experiments that have been tried with porcelain, it is still considered the best and cheapest material for this service. However, in transmission work, one of the great advantages claimed for glass in telephone and telegraph practice disappears. The engineers of these companies claim that it is important to provide against dark, narrow spaces within the insulators on account of the fact that they form the homes of insects. The transparency of the glass largely obviates this difficulty. Where large insulators are used, such as are employed by transmission companies, the spaces within the insulators are well lighted from below, and the transparency of the material is not important.

Glass is comparatively fragile, and for transmission work it has nothing to recommend it except low first cost and cheap inspection; these, to be sure, are very often overpowering advantages when the voltage is low enough; for that, the particular form of insulator used gave a large factor of safety and, in consequence, up to 15,000 volts, glass insulators are generally preferred, unless there are special climatic conditions which render them liable to fracture. Many series of tests have shown conclusively that the porcelain insulator has a greater mechanical strength, is less liable to surface leakage, has a safe dielectric strength, and, in addition, that it is exceedingly difficult to so break the head of a porcelain insulator as to allow the wire to fall away from it. The one disadvantage of porcelain is that there is an uncertainty as to its solidity, and that it is only possible to ascertain its solidity by most careful high-voltage tests.

The question of the form of high-voltage insulator as yet is in high dispute, operating engineers being inclined to a design in which the petticoats are very long and comparatively close together, so that great creeping distance be given over the surface of the insulator between line and line and between line and pin, comparatively little importance being placed on the flashing distance. Engineers of the manufacturing companies, however, incline toward one of a much more open type of large diameter and with few petticoats. This latter form undoubtedly gives the greatest sparking distance, has the least dark spaces within it and is more readily cleaned by rainstorms. It is also important that such an insulator may be constructed to operate at high voltage without noise, and as there is a definite loss of energy whenever the insulators on a line are noisy, it may be safely predicted that the open type of insulator is to be the one that will in the future be considered as the standard.

While for a particular voltage insulator size may be largely determined by the form, at the same time we may in general note that, up to 10,000 volts, insulators, whether of glass or porcelain, have a minimum diameter of about 5 inches. A 7-inch insulator can successfully be used on voltages as high as 25,000, a 13-inch insulator is sufficient up to 40,000 volts, while at 60,000 volts it does not seem safe to install insulators having less diameter at the top than 14 inches. A greater size would unquestionably be used invariably for these high voltages if the problems of the manufacture of porcelain and support of the insulator were altogether solved.

Insulators above 8 inches in diameter are generally manufactured in several parts, and are either glazed together in the porcelain kiln or cemented together in the field. This method of construction allows a more thorough inspection of the constituent parts for solidity of material and also reduces the loss from breakage in transit. It has the disadvantage of introducing into the insulator a variable dielectric which, however, in line insulators has not been proved to be a disadvantage.

Attempts have been made to construct an insulator of two materials, such as glass and porcelain, but all such attempts have been now abandoned and the separable insulator is now constructed entirely of porcelain united with Portland cement.

In supporting insulators on cross-arms it is necessary to provide that the lowest petticoat be raised above the cross-arm as much as the radius of the insulator, and, as the strain comes on the extreme top of the pin, it is obviously difficult to successfully support the largest size of insulators by means of the common pin and cross-arm construction. By using carefully selected woods, this has been successfully accomplished for insulators up to 11 inches in diameter; but at 40,000 volts in bad weather such insulators carry enough current over their surface to char a wooden pin. Accordingly, practice has settled to the use of iron pins in plants operating above 25,000 volts. At this voltage and below, the wooden pin can be successfully used and, indeed, forms a certain protection to the line by reason of the fact that the pin itself is a semi-insulator, and is in danger of being burned only when the insulator is punctured.

Above this voltage, however, only metal pins can be employed, not only on account of the large size of the insulator, but also on account of the fact that there is much burning of wooden pins. The manner in which these pins are burned has attracted considerable attention, having presented some problems which are exceedingly interesting. There is no doubt but that the effect is due to leakage over the surface of the insulator, but it is extremely interesting to note that in some cases the pin is actually charred, whereas in other cases there is an apparent disassociation of something in the wood, and peculiar salts are left behind, reduced either from the atmosphere or from the material of the wood itself. This matter was discussed by Mr. C. C. Chesney in a paper read

before the American Institute of Electrical Engineers.

The materials that may be used for wooden pins are locust and eucalyptus. The latter wood is decidedly preferred in the plants west of the Rocky Mountain region and where it is readily available, as the wood has been found to be as strong as hickory, dense, and readily handled when thoroughly seasoned and dried. For the largest sized pins, however, as has already been said, no wood is entirely satisfactory, and in consequence use is made of malleable cast-iron or cast-steel.

As regards conducting material, it may, of course, be said that the only materials at present available are copper and aluminium. For a number of years there has been a discussion of the possible use of iron for short lines on high-potential plants, since the smallest copper wire that may successfully be strung is unnecessarily large under such circumstances. This procedure, however, has not obtained the approval of any of our electrical engineers. The copper wire is invariably uninsulated in high-tension work, since it is correctly believed that no insulation is a true protection, and the frank nakedness of the bare wire is a warning and, in consequence, a safeguard to those who are compelled to work near the line.

Copper is used either soft, hard-drawn or stranded. For transmission work, when the wires are smaller than 0.3 inch in diameter, use is not made of soft-drawn wire, and it may be stated that the standard in American practice is to use soft-drawn wire for only large, low-potential circuits where the small change in conductivity due to the hard drawing is an important factor. Up to 0.3 inch hard-drawn copper may be considered standard. Between 0.3 inch and 0.4 inch diameter the practice is evenly divided between solid, hard-drawn wire and strand. A diameter larger than 0.4 inch strand is almost invariably employed. Some use has been made of solid aluminium, but, as the material must be handled with great care, it has been found generally to be the better practice to employ aluminium strand, which is more readily installed and more reliable after installation.

Preference between aluminium and copper is almost entirely a matter of price for transmission lines. It is true that aluminium is stronger in reference to its weight for the same conductivity than copper, but at the same time it is materially larger, and the resultant transverse wind stress on the line is greater. For short lines, delivering a small amount of power at voltages of 40,000 or above, aluminium is decidedly to be preferred, since it is found that at these voltages a wire less than ¼ inch in diameter will discharge through the air, and this discharge may result in a considerable loss of energy. It is, therefore, not possible at these voltages to successfully use wires less than 0.3 inch in diameter, no matter what the amount of energy or the distance. Accordingly, where the amount of energy and the distance may result in the loss not being the determining factor, aluminium is much preferable for the reason that at a definite size it is materially cheaper than copper.

Where salt-sea fog is to be encountered, both aluminium and copper are acted upon. The action on aluminium is greater than the action on copper, and in consequence copper must necessarily be used. Where such conditions are not encountered, aluminium is an entirely safe material provided it is not exposed to the elements in contact with any other metal. The joints, therefore, must either be made of aluminium of the same quality as the wire, or the joints must be carefully insulated so that no moisture will penetrate. Aluminium must be strung with careful reference to the temperature at the time of erection, since its coefficient of expansion is very large, about three times the coefficient for copper, and experience in the erection of copper lines will result in an unsafe aluminium line. Careful tables have been prepared as to temperature, span and sag, and, where these tables are followed, no apprehension need be felt as to the safety of the line.

The most difficult problem at present encountered in the construction of high-tension transmission lines is that presented by the lightning arresters. For voltages up to 25,000, the non-arcing types of lightning arresters, either with or without series resistances, may be successfully used. Above this voltage and where large amounts of energy are available, these arresters are found to be short-lived, and up to the present time no thoroughly satisfactory arrester has been presented which does not, when interrupting the ground circuit after a discharge, injure the insulation of the line and transformers.

The horn form of lightning arrester developed in Germany has been found to operate with invariable success so far as the lightning arrester itself is concerned, but, as it is interrupting the ground circuit, it draws a large arc, and oscillations are produced on the line, which in many cases have been found to have more serious results than the discharge they were installed to remove. Condensers in parallel with the lightning arresters and ingenious arrangements of condensers and resistances have been used with some success, but none of these plans may be considered to be entirely satisfactory for the highest potentials operated from the largest generating plants.

In the operation of such lines every effort is made toward maintaining continuity of service. Such lines are carefully patrolled, even when it becomes necessary to build a special runway for the patrolman, and it is remarkable with what certainty these experienced men can predict the hours of life of a failing insulator and provide for voluntary interruption of the service in time to remove the imperfection. Duplicate lines for long-distance work are an invariable necessity, though by far the best protection that can be offered for service is the supply of current from different power stations over lines following different routes. The present tendency is toward the consolidation of plants, not only for the purpose of decreasing the general operating expense, but more particularly for providing continuity in the case of the most serious accidents. No difficulty is experienced in operating in parallel plants widely separated, and where a number of plants are feeding into the same network, to certain plants are assigned the regulation of the entire system, others feeding the circuit being allowed to operate their machinery at full load continuously.

The line capacity offers the most serious problem in determining regulation where the loads vary widely, but this quality becomes important only for great variations of load, which, as the plants increase in size and load, are disappearing. Where proper care has been given to the installations of the lines and where duplicate lines and plants are provided for, care in operation and patrol of the lines has resulted in success from both the engineering and the financial standpoint.

Referring to the article in the August, 1904, issue of this paper, describing the 100-mile electric transmission plant of the Washington Water Power Company, at Spokane, Washington, attention has been drawn to a possibly misleading title underneath one of the illustrations which would seem to make it appear that the total horsepower available is only 4000. As a matter of fact there are in actual running condition or nearly ready, 15,000 H. P. water wheel capacity, the transmission line being the minor part of the plant.

Single-Phase Alternating-Current Railways

For Interurban Service

THE rapidity with which old standards are replaced by new and the slight extent to which electrical practice is hampered by tradition or adherence to established methods, finds an example in the complete change in sentiment regarding the possibilities of the single-phase series motor for traction purposes that has taken place since Mr. B. G. Lamme, chief engineer of the Westinghouse Electric & Manufacturing Company, first made public the results of his researches along this line.

Three years ago, European engineers were devoting their efforts to overcoming the inherent defects of the polyphase motor for railway service and had, evidently, finally decided to use polyphase systems. American engineers were decidedly skeptical as to the ability of any one to produce an alternating-current railway system that could be operated economically or satisfactorily, or alternating-current motors with the proper characteristics for railway service.

This was shown by the many doubts expressed at the meeting of American Institute of Electrical Engineers, about two years ago, at which Mr. Lamme presented his first paper. To-day, the general verdict is that the alternating-current railway system is not only entirely practicable, but that alternating current is destined to become the motive power in general use for traction purposes. Moreover, it is now generally acknowledged that the straight series alternating-current motor, brought out originally by the Westinghouse Company and since adopted by other companies, is the most practical form of alternating-current railway motor. Other types have been tried and abandoned.

The alternating-current railway motor is not a new and untried experiment. Previous to 1902, when Mr. Lamme first publicly advocated the use of single-phase alternating current for railways, a long series of tests at the Westinghouse shops had demonstrated the value of the series alternating-current motor. In addition to these, a number of 40-H. P. motors of this type had been operated continuously for nine months in a certain outside manufacturing plant. Since that time, the Westinghouse engineers have been actively engaged in perfecting the details of the other apparatus required to complete the system. For nearly two years, a car equipped with these motors has been in almost daily use upon the Interworks Railway between East Pittsburg and Wilmerding, and systems of regulation and control suited to various operating conditions have been devised.

The Westinghouse single-phase motor was described in the issue of this journal for February, 1904, so that without repeating the description here we may pass at once to the other parts of the system. It is sufficient to say that the motor possesses the same speed and torque characteristics and practically the same weight per horse-power as the best direct-current motors now in use. It is, in effect, a straight series motor carefully designed for use on alternating current. The chief reason for its prominence is not in the motor per se, but in the fact that its development allows the use of alternating current throughout the entire system.

To the merits of the direct-current railway system, which the alternating system retains, are added others peculiar to the use of the alternating current. Prominent among them are the removal of the voltage limit, which lessens the cost of transmission and also simplifies the problem of collecting large amounts of power through moving contacts for the operation of heavy trains; the higher efficiency of transformers as compared with direct-current rotary converters in sub-stations and an increased car efficiency by the elimination of rheostatic losses, thus lessening the amount of power

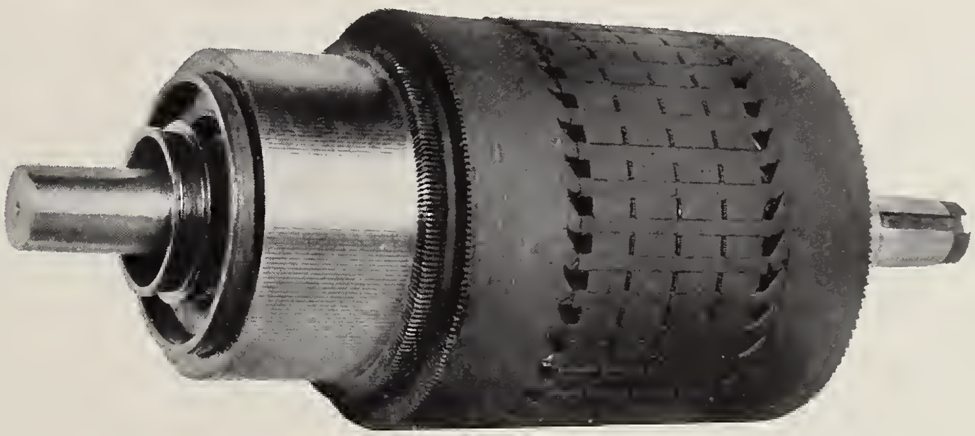


FIG. I.—THE ARMATURE OF THE WESTINGHOUSE ALTERNATING-CURRENT RAILWAY MOTOR

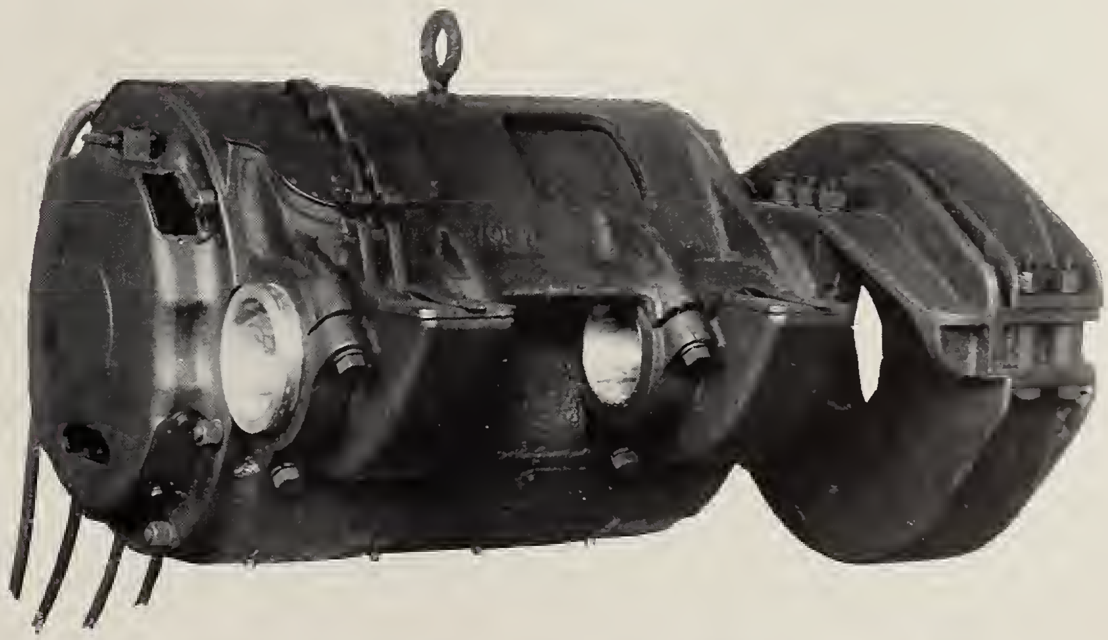


FIG. 2.—THE WESTINGHOUSE ALTERNATING-CURRENT RAILWAY MOTOR

FIG. 3.—CAR ON THE WESTINGHOUSE INTER-WORKS RAILWAY, EQUIPPED WITH ALTERNATING-CURRENT APPARATUS, TROLLEY AND LINE CONSTRUCTION FOR 1000 VOLTS AND LESS

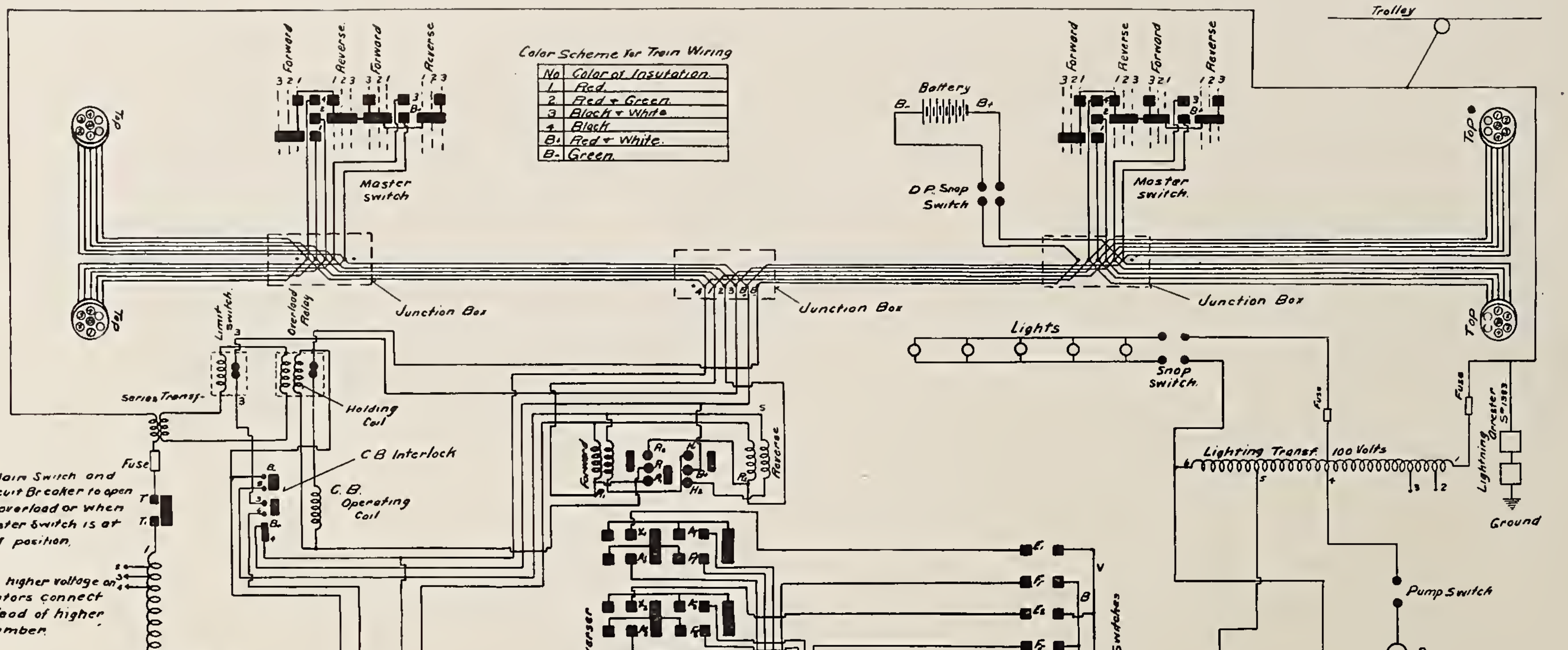


FIG. 4.—WIRING DIAGRAM OF THE WESTINGHOUSE ALTERNATING-CURRENT SINGLE-PHASE CAR EQUIPMENT

required to operate the system; the wide range of speed control, as hereinafter described, and the disappearance of electrolysis. There is also a material saving, both in initial expense and the cost of operation and maintenance. The cost of the alternating-current car equipment is considerably more than that of the direct-current equipment, but the saving in transmission circuits and the omission of the rotary converters in the alternating-current system, and the saving in other respects, leave a large balance in its favor.

CAR WIRING

There are three electric circuits upon each car, as shown in Fig. 4.

1. The motor circuit. In this circuit there are placed the circuit breaker, main transformer, induction regulator, reverser, motor cut-out switches and motors.

2. The auxiliary control circuit. An electro-pneumatic system of control is used, the various parts being operated by compressed air controlled by magnet valves. Current for the magnet valves is obtained from a 14-volt storage battery placed under the seat of the car. The use of a separate low-voltage circuit for this service is a valuable factor of safety. The fact that the control circuit is independent of the line and can be used whether the trolley is in use or not is also an advantage.

3. The lighting and heating circuit. This contains the necessary apparatus for lighting and heating the car and also the air compressor motor with its governor. It is taken from the line by a second transformer. This circuit is not connected with the motor circuit.

THE MOTOR CIRCUIT

The motor circuit begins with an auto-transformer of special design connected between the trolley wire and the ground. This transformer is so arranged that the current of air created by the motion of the car circulates through it, thus keeping it cool. A view of this transformer, as mounted beneath a car, is shown in Fig. 5. At a point approximately 230 volts from the ground a circuit is led from this auto-transformer through the secondary of the induction regulator, and another tap, approximately 650 volts from the ground, is led through the primary of the regulator. The exact wiring of this arrangement is shown in Fig. 4, and the diagrammatic arrangement in Fig. 7, which is somewhat modified for greater clearness.

Between the auto-transformer and the trolley is placed the circuit breaker which acts also as a main switch, and not only automatically opens the circuit when an overload occurs, but also whenever it is desired to cut off the current from the car. This circuit breaker is held in place by a compressed air cylinder working against a powerful spring. When the air is allowed to escape, the spring opens the breaker. The admission or release of air from the pneumatic cylinder is controlled by means of magnetic valves.

FIG. 5.—AUTO-TRANSFORMER IN MOTOR CIRCUIT ON CAR

The voltage applied to the motors, and consequently the speed of the car, is governed by the induction regulator. This is, in effect, a transformer, with its primary core and winding movable with respect to the secondary. It is operated by means of a small pneumatic motor controlled by electro-magnetic valves, and may be turned so that its voltage either opposes or aids that of the auto-transformer any amount within the capacity of the regulator. In the "off" position the full voltage of the regulator is opposed to the 230-volt circuit of the auto-transformer, thus giving a low voltage for starting the motors. At the "full-on" position the entire voltage of the regulator is added to that of the 230-volt circuit of the auto-transformer, giving the proper voltage for full speed running. The regulator can be left indefinitely in either of these positions or in any intermediate position, and thus the car can be run at any desired speed.

The reverser, as its name implies, changes the connections of the motor armatures with reference to their fields, so that the car may be run either forward or backward. The reverser is operated by means of two pneumatic cylinders, one throwing it forward and the other backward. Air is admitted to either cylinder when desired by means of a magnetic valve.

The motor cut-out switches consist of a double-pole switch for each motor, all mounted together and enclosed in a suitable iron case. In case of damage to any motor, the injured one can be cut off entirely from the circuit and the car then operated with the remaining motors.

The motors are permanently connected in parallel, the advantages ordinarily derived from a series-parallel arrangement being obtained directly through the use of different positions

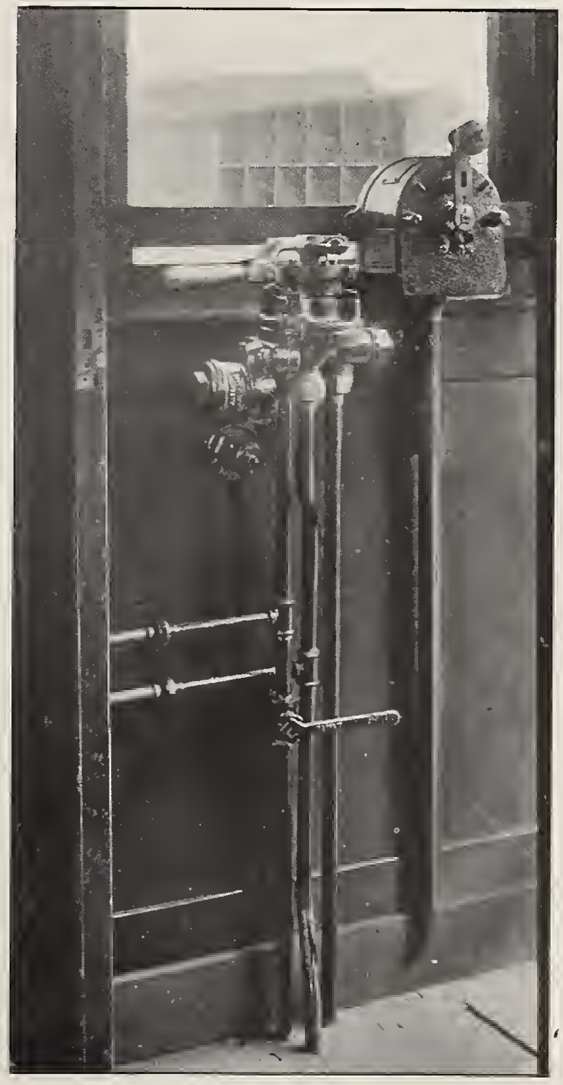


FIG. 6.—THE MASTER SWITCH ON THE CAR PLATFORM

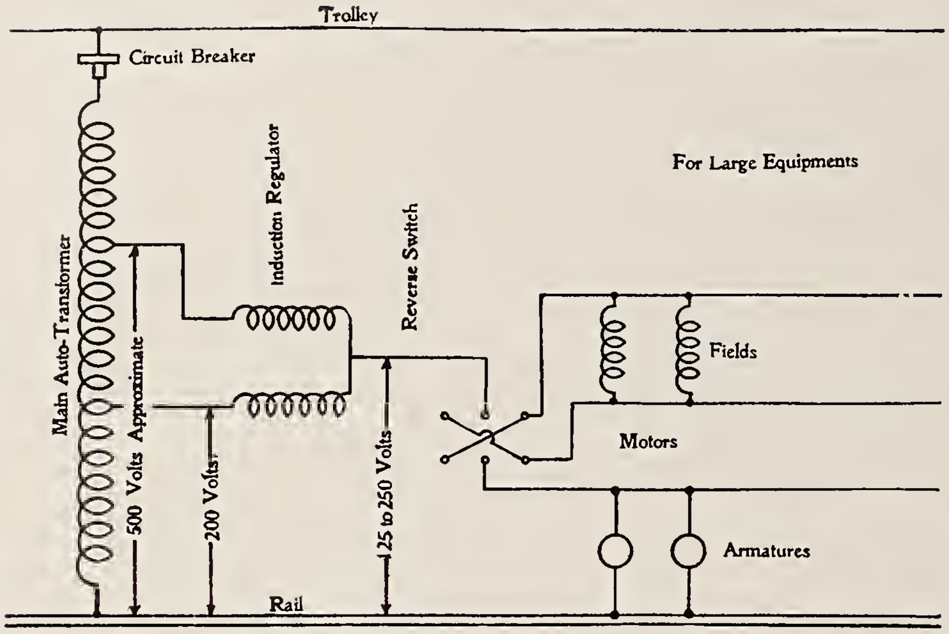


FIG. 7.—ARRANGEMENT OF MOTOR CIRCUIT

of the induction regulator, without changing the connections of the motors with respect to each other. As the motor voltage is independent of the trolley voltage, a standard of 250 volts has been adopted, irrespective of the voltage of the trolley.

CONTROL CIRCUITS

The operation of the various magnet valves which regulate the movement of each of the above pieces of apparatus is controlled by means of a master switch located on the platform of the car. A view of this switch, together with the motorman's air brake valve, is given in Fig. 6. There are but three positions for the handle of the master switch for operating the car in a forward direction, and three corresponding positions for backing. When the handle is turned to the first notch on either side, connection is made with the magnet valves governing the reverse switch. Air is admitted to the proper cylinder and the reverser is thrown to the proper position. When the reverse switch has been operated, air is admitted to the pneumatic cylinder of the circuit breaker and the circuit breaker is then closed. This applies current to the motors and the car starts.

To secure a higher speed, the handle is thrown to the third notch, which closes the circuit to one of the magnet valves controlling the pneumatic motor which drives the induction regulator, and air is thus admitted to the air motor. The regulator is then turned, gradually raising the voltage at the terminals of the motors. If the handle of the master switch is left on the third position, the regulator will advance to the "full-on" position, where it will be automatically stopped.

If it is desired to operate the car at anything less than full speed, the handle of the master switch may be brought back to the second position and the regulator will at once stop and remain stationary. Under such circumstances, if the handle is again moved to the third position, the regulator will advance and increase the voltage at the motors and consequently the speed of the car. If the handle is moved back to the first position, the regulator will return toward the mini-

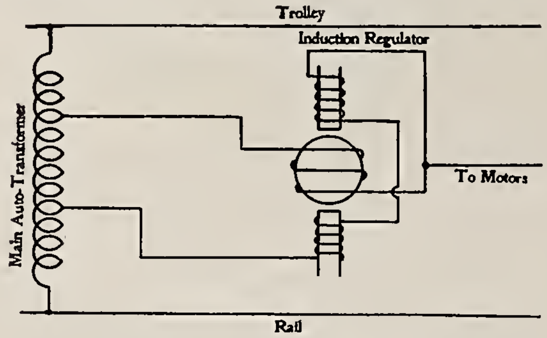


FIG. 9.—INDUCTION REGULATOR CONNECTIONS

mum position, lowering the voltage on the motors, thus lowering the speed of the car.

If at any time it is desired to cut off the current, the handle of the master switch may be returned to the "off" position, in which case the circuit breaker will open at once, thus cutting off the current immediately. After the circuit breaker has been opened, the regulator will return toward the minimum position and the circuit breaker, having once been opened, cannot be closed again until the regulator has reached the position of minimum voltage.

The circuits leading to the circuit breaker and reverser are so interconnected that the circuit breaker cannot be closed until the reverser has first been thrown, nor can the reverser be moved unless the circuit breaker is open.

The arrangement described can be adapted for multiple control by the addition of leads, connection boxes and "jumpers" for forming a continuous control circuit over the different cars, no other change being necessary.

The advantages of this method of speed control, as compared with rheostatic control, are evident. The elimination of resistance losses, the ability

FIG. 8.—THE BOW TROLLEY

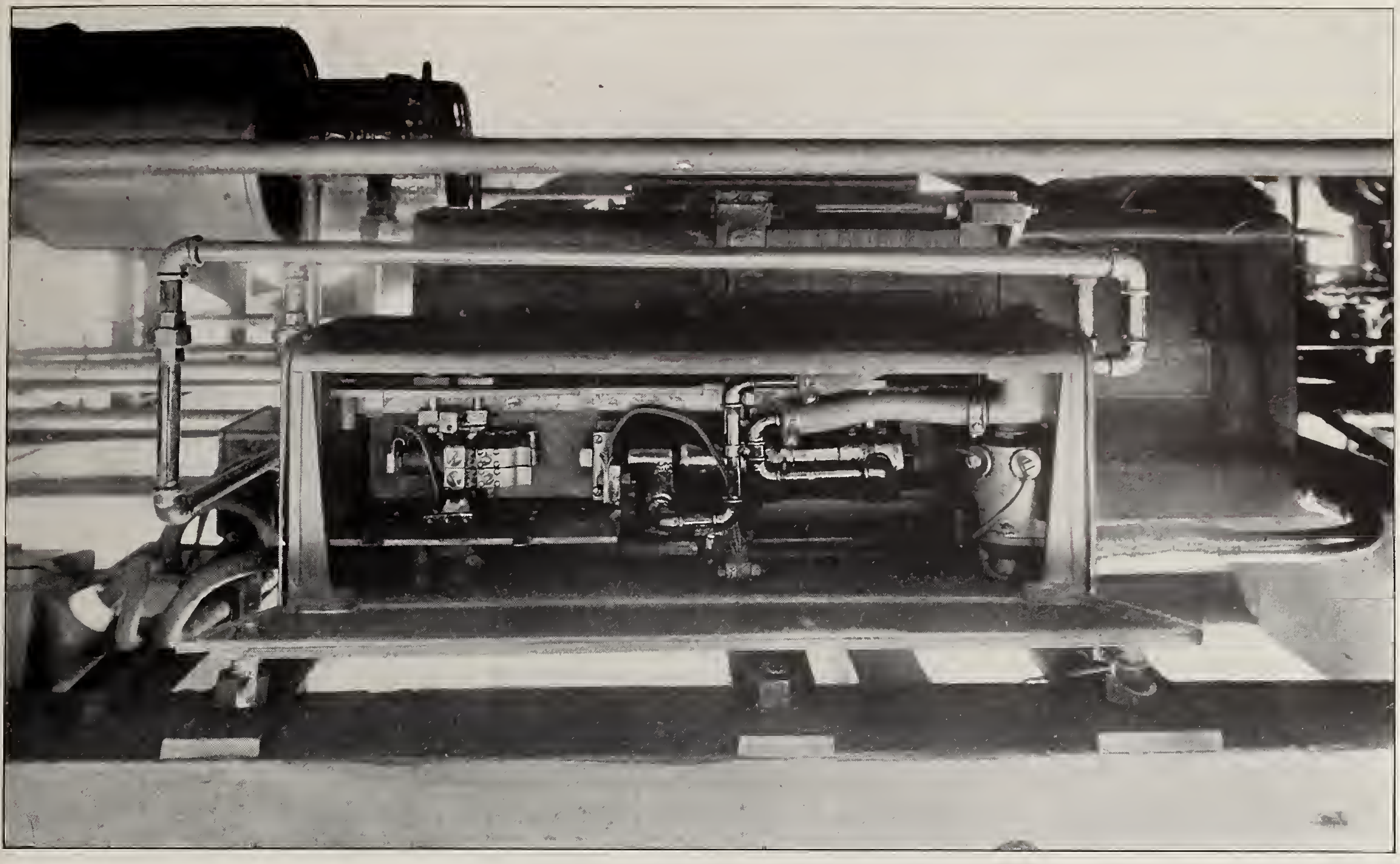


FIG. 10.—CIRCUIT BREAKER AND AUTO-TRANSFORMER

FIG. 11.—THE CATENARY TROLLEY LINE

to change speeds without opening the circuit, the fact that every speed may be used for continuous running, and the ease and flexibility of control are important benefits thus derived.

LIGHTING AND HEATING CIRCUIT

The lighting and heating circuit is operated from a small auto-transformer similar in design to the one in the motor circuit. From this transformer are supplied the lights in the car, the heating circuits, if any, and the small motor for operating the air compressor. The latter may be controlled by an automatic governor or by the hand switches, which are conveniently located.

TROLLEY AND OVERHEAD WORK

Where the voltage of the line is 1000 or less, connection between the car and the trolley wire is established by means of a trolley of the ordinary type. For higher voltages, a trolley of the bow type, especially designed for the purpose, is used. This is raised and lowered by compressed air under the control of the motorman, and any danger from shock in handling is thus avoided. In Fig. 8 it is shown in the running position. The two levers at each side are so arranged that when the pneumatic pressure is removed the trolley lies flat upon the top of the car. When the air is applied, the result is, first, to raise the upper section at about the angle illustrated, and then to lift the entire trolley to the running position. The main spring keeps the trolley upright, but permits it to give under pressure.

When the direction of the car is reversed, the upper portion of the trolley is slanted in the opposite direction. The side springs in the levers, which support the upper portion of the trolley, adjust it for variations in the height of the wire, and the trolley is thus kept in contact with it and a continuous unbroken current results. With ordinary variations, the position of the lower portion of the trolley remains unchanged, the fluctuations affecting only the lighter upper section and insuring a sensitive action. The chief advantages given by the trolley are the substitution of pneumatic for hand control, with the consequent elimination of all danger from grounding through the hand rope; a continuous contact with the trolley wire, and the impossibility of the trolley slipping off the wire and damaging the overhead structure.

At each support the trolley wire is attached at a point alternately 12 inches to right and left of the center of the track, so that it is staggered, and the contact between it and the trolley varies from one side to the other; thus, undue wear at any point is prevented.

The overhead structure, which is of the catenary type, is illustrated in Fig. 11. The trolley wire is suspended from a messenger cable by hangers of different lengths, so graduated that the wire is at all points parallel with the track, presenting the best possible condition for continuous contact under high speeds. This construction also gives greater rigidity, with the absence of up-and-down or sidewise motion, an increased strength and consequent ability to support loads of ice in winter storms; and strength and simplicity in all parts that minimize repairs and, in general, an efficiency in keeping with other portions of the system.

This catenary structure can be suspended from side brackets, as shown, or the ordinary span construction can be adopted. Grooved trolley wire is used, and since it is supported at frequent intervals, great rigidity can be obtained with a small size of wire. Suitable details of construction for use upon curves of different radius, of anchors, steady strains, section breaks, turn-outs, etc., have also been carefully designed.

A study of the system, as briefly outlined, shows a consistency in theory and design which has been followed throughout the different pieces of apparatus and which produces an unusual degree of efficiency and general harmony. The completeness with which all details have already been worked out, together with the saving in both initial cost and expense of operation and maintenance, make it safe to predict the general and rapid adoption of this system for high-speed interurban traction. The field for development is a wide one.

The way is also opened for the adoption of the system in city service, where perfect control in conjunction with economical consumption of energy in starting are of particular value; and for its use also in heavy units, such as are now confined to steam railroads, so that the development of this system may be regarded as a step toward the anticipated substitution of electricity for steam.

The Boston Submarine Signal Company, by agreement with the Canadian Government, is to install thirty bells in the St. Lawrence River and off the coast of the maritime provinces. Twenty-six of the stations will be worked from shore and four from lightships. In order to use the system, ships are equipped with telephone receivers, which pick up the sounds of the bells at a distance of 4 to 10 miles.

The Destruction of Harmful Insects by Electricity

IN a recent number of the "Elektrotechnische Zeitschrift" particulars are given of some experiments carried out by the Russian Technical Society of Odessa on the destruction of insects, larvæ and grubs on agricultural land by electrical means.

A small dynamo was arranged on a wagon, either drawn by horses or driven by a petrol motor, and the dynamo was driven by spur gearing from the wagon axle. Its terminals were connected through a Wehnelt interrupter to a sparking coil. The high-tension secondary of this coil had its negative terminal connected to earth through the wagon and its positive terminal to a number of metal brushes fixed under the back part of the wagon and arranged to be vertically adjustable.

A broad body of sparks was in this way made to pass from the brushes to earth and killed any insects lying on the surface. It was observed that in the case of certain classes of insects—beetles—the high-tension current acted on the nerve system first and disabled single limbs. In the case of grubs an electrolytic dispersion of the fluids seemed to take place simultaneously. Insects which were not killed instantly, but could still move one or more limbs after the passage of the wagon, died in a short time from the after effects.

It is proposed to drive the wagon immediately behind the plow, as the turning up of the earth naturally exposes countless insects and larvæ. The practical value of the apparatus is hardly established yet, but the experiments are to be continued in the spring with a view to exterminating the turnip-fly found so plentifully all over Russia.

The fight with these insects absorbed over 4,000,000 marks in the year 1901-2 in the government of Kiev alone, and in South Russia an annual expenditure of from 10 to 20 marks per hectare is made for the same purpose. These figures show that the apparatus, which costs only about 5000 marks, would soon pay for itself should it prove effective in practice.

The French Government have decided to cross the great Sahara from South Algeria to the west coast by an electric cable, which is to be laid from In-Salah, via Tidekalt and Tageneut to Timbuctoo. The distance is about 620 miles, and the estimated cost amounts to $300,000. The work is to be completed in about twelve months.

Thawing Out Frozen Water Pipes Electrically

By WILLIAM MAVER, Jr.

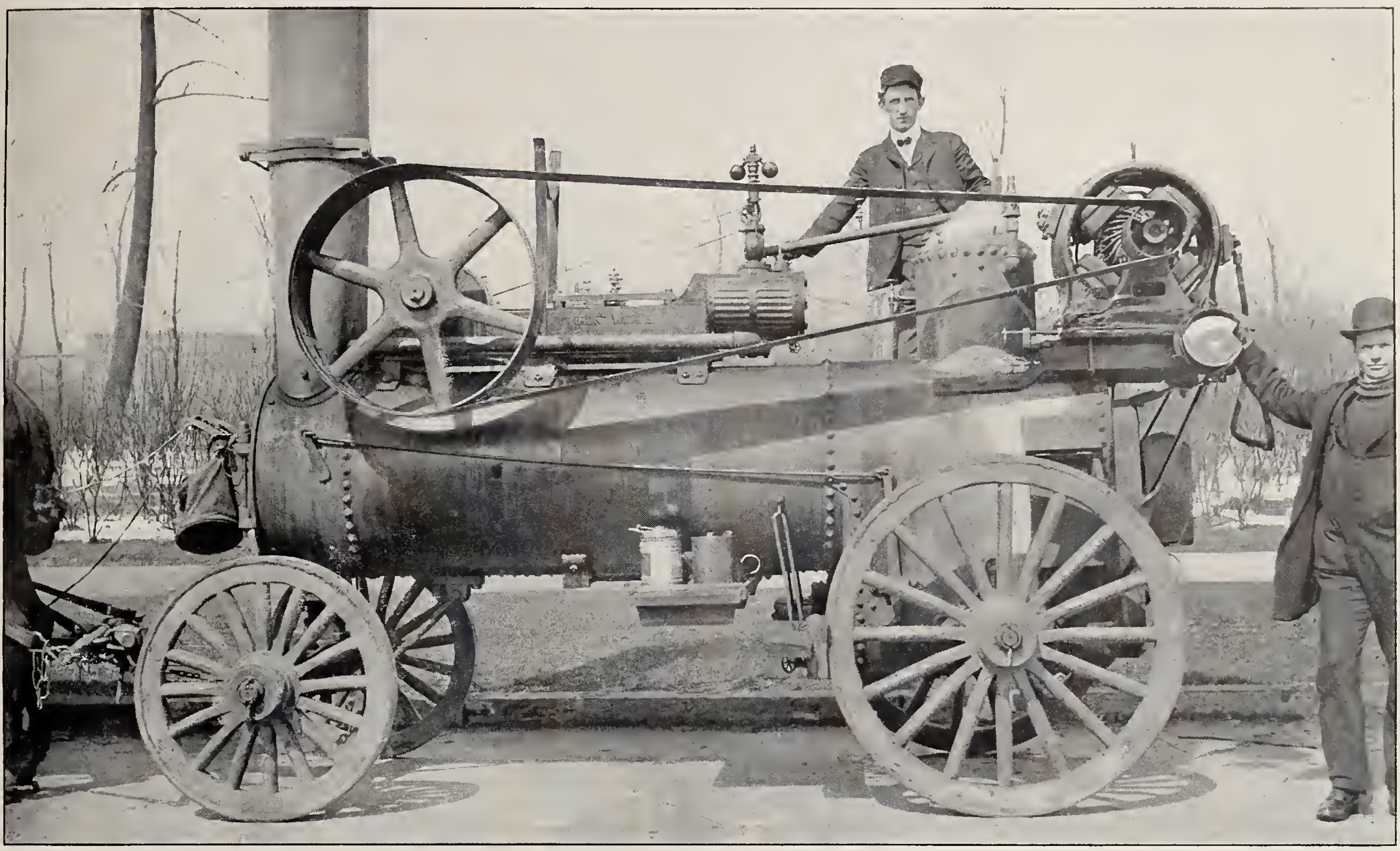


FIG. I.—A PORTABLE GENERATOR OUTFIT FOR SUPPLYING CURRENT FOR THAWING OUT FROZEN WATER PIPES IS USED IN SOME PLACES WHERE ELECTRIC STREET MAINS ARE NOT AVAILABLE

THERE are a number of claimants for the credit of having first utilized the electric current for thawing out frozen water mains and service pipes. The process appears to have been first applied in the winter of 1898-99, in Chicago and other Western cities, and in Canada. It is said that one of the first users of the process applied for a patent covering this use of electricity, but the patent was refused on the ground that it did not possess any novelty, or that it was too simple.

The principle employed is, of course, quite simple. An electric current is completed through the frozen pipes by attaching one wire of a circuit to a street hydrant, and the other wire of the circuit to the water pipe within a building. Since the iron pipes are much better conductors of electricity than the frozen earth the electric current follows these pipes, heating them to a temperature sufficient to thaw the ice in a comparatively short time.

It can hardly be said, however, that this was a self-evident proposition at the time the patent was applied for, and the fact that the more or less general use of this method followed and did not precede the announcement of the feasibility of the plan, may be assumed to show that it might have required some invention to prove the practicability of the process. Before leaving this part of the subject it may be remarked that there is a tradition, which is probably susceptible of confirmation, that in the early days of the New York electrical cable subways, about 1890 to 1893, it was not uncommon to send a strong current through the lead covering of cables in the ducts to loosen the grip of ice upon them in winter, when it was desired to draw the cables out of the ducts—a method which might be considered by some an anticipation of the process in question.

It is generally well known that the plumbers' method of thawing out frozen water service pipes is a cumbersome one. In fact, these gentlemen have at least two plans of procedure. One consists in opening the service pipe at a stop-cock within the premises and inserting into the pipe a rubber tube as far as practicable, which if the water pipe is reasonably straight, will be up to the ice. Steam is then injected into the rubber tube and gradually thaws the ice, the rubber tube being pushed further and further in as the ice melts; but there seems to be a well-defined limit in this case beyond which the steam will not carry effectively. The plan is sometimes successful, but has the disadvantage that it is not always possible to readily stop the rush of water at the open end

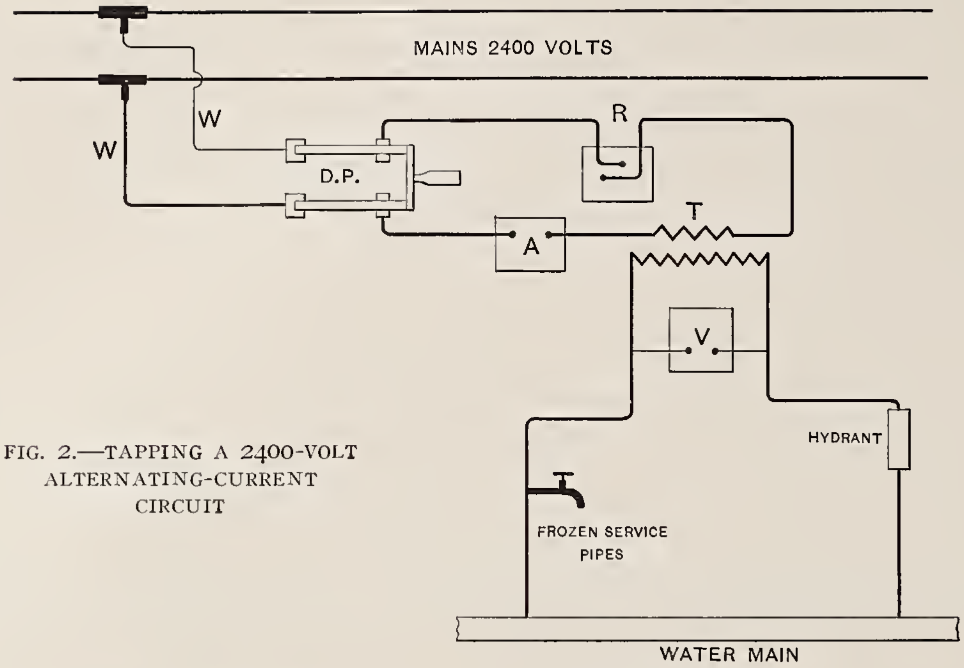


FIG. 2.—TAPPING A 2400-VOLT ALTERNATING-CURRENT CIRCUIT

of the pipe when the ice gives way. Another plan of the plumber, and the one heretofore most generally followed, is to build a fire of wood, coke or coal on the surface of the ground over the water pipes for the purpose of thawing the earth to permit digging down to the pipes, to which heat may be applied externally. This plan is tedious and expensive, and even the plumbers themselves are said to hail with pleasure a method for remedying this trouble which will relieve them of the odium attaching to the profession because of some of the bills to which the digging method has given rise.

The excessive bills referred to are due to the fact that the fire has to be kept going constantly for twenty-four or forty-eight hours, in some cases, and with the double pay for overtime and night work the labor item is large. Bills for $100 for thawing pipes by this process are not uncommon in some cities. There is also the likelihood that, with the earth loosened, the water pipes may freeze again at the same place within a few hours, if cold weather continues.

The plan of thawing out the pipes by heat generated electrically is, on the contrary, clean, expeditious and comparatively inexpensive, and especially in the Eastern States it has been largely resorted to where, owing to the long continued cold weather, the cases of frozen water service pipes in some of the cities have been numbered by the hundreds. In one city alone, of which the writer has knowledge, over 600 frozen water pipes have been thawed out by the electrical process.

There are a number of different methods of bringing the current to the frozen pipes, and almost every ordinary source of electromotive force may be made available for this work by suitable connections and apparatus. There are, of course, some exceptions to this statement, as, for instance, underground electric cables, which cannot readily be tapped. Overhead lighting and power circuits, too, are available only when they are in the vicinity of the frozen pipes; this, however, has proved to be the case in numerous instances.

One method of arranging the connections and apparatus for tapping a 2400-volt, alternating-current overhead circuit is shown in Fig. 2. The temporary connections are made on live wires, and consequently much care on the part of the linemen is necessary. To make the taps, the insulation is scraped off the overhead conductors and the leads *W W,* which may consist of No. 12 or larger copper line wire, are connected to them by a suitable *T* clamp; or the leads may be simply twisted around the conductors.

To facilitate making connections with the overhead circuits and with the city hydrants or faucets within the buildings, at least four sections of well insulated wires, from 100 to 400 feet in length, and of ample capacity to carry the heaviest currents that may be used without undue heating, ought to be carried with the outfit. The terminals to be attached to the line conductors may be provided with close-fitting couplings. In some places sections of No. 000 copper wire have been used for this purpose.

The apparatus indicated in the diagram consists of a double-pole switch, *D P,* a water rheostat, *R,* an ammeter, *A,* an 11-K. W. transformer, *T,* and a voltmeter, *V,* all of which are carried to the scene of action on a wagon. The water rheostat is employed to reduce the voltage to a desired amount, say 20, 50 or more volts in the secondary circuit. In some cases the water is contained in a wooden barrel or in a wooden bucket.

In one arrangement of the water rheostat a coil of bare copper line wire is placed in the bottom of the barrel for one terminal. For the other terminal a number of ordinary arc carbons, tied together by the lead wire, are used; or bare wire alone may be used for such terminals. To increase the conductance of the water, salt may be added, but this is not always considered necessary. When a small vessel is used for this purpose, copper plates are preferable for the terminals. These plates are placed at least 6 inches apart. When heavy currents are passed through these rheostats the water may show a tendency to boil,

FIG. 3.—IN SOME TOWNS A PORTABLE MOTOR-DRIVEN GENERATOR OUTFIT IS USED IN PLACE OF WATER OR OTHER RHEOSTATS

which may be prevented by the addition of ice or cold water.

By means of the ammeter, *A*, in the primary circuit, the current in the secondary circuit may be calculated, the ratio of transformation being in this case say 40 to 1, and the voltage may be read from the voltmeter, *V*. When barrel rheostats are used, it is good practice to begin with the terminals about 30 inches apart, gradually shortening the gap. It may be added, however, that after considerable experience in this work with high potentials, some workers have dispensed with the water rheostat altogether, owing to the danger from shock connected with its use. When this is done, reliance is placed entirely upon instances were thawed out in a few minutes.

Another outfit for this work that has been used successfully in connection with 1000-volt overhead circuits consists of three 6-K. W., and two 4-K. W. transformers arranged to be used jointly or separately to give 50 or 100 volts, and 100 or more amperes in the secondary circuit.

While such high potentials as those stated have been used quite extensively for the work in question, with success and without accident, so far as known, it is obvious that there is an element of danger in the handling of the apparatus and in the possibility of grounding the primary circuit through the transformers. There is also a

FIG. 4.—CONNECTING A WATER OUTLET WITH THE ELECTRIC CURRENT SUPPLY

the transformer to reduce the voltage to a fixed standard for all cases met with in ordinary work of this kind.

Reactance coils are sometimes used in place of the water rheostat, and there are, of course, other well known means by which the voltage may be controlled without recourse to resistance coils or rheostats; for instance, by winding the transformer so that by a change of the connections any electromotive force in steps of 5 or 10 volts, up to 50 or 100 volts, can be obtained in the secondary circuit.

Another arrangement used on a 2400-volt alternating-current circuit consists of the usual rheostat or reactance coil, switch and ammeter, together with two 20-K. W. transformers with the primaries in series and the secondaries in multiple, giving an electromotive force of about 60 volts and 50 to 75 or more amperes in the secondary circuit. With this amount of energy the frozen pipes in numerous mild objection in some places to the use of the alternating current for this work, namely, that when connected to the water pipes it has been known to set all the telephone bells in the town ringing—at least all those having ground connections.

In Fig. 5 are shown the connections from a direct-current, overhead lighting system as utilized to thaw out the frozen pipes in adjoining houses, the connections being made to the water faucets in each building. The pipes in a row of eight houses were speedily thawed in turn by this process. Here the electromotive force on the lighting mains is 220 volts, and in some cases the ammeter indicates over 125 amperes on the water pipes, the current being increased gradually by means of the water rheostat in the manner stated. In other instances the current was increased to 180 amperes before the water flowed. In this use of the direct current, some form of resistance

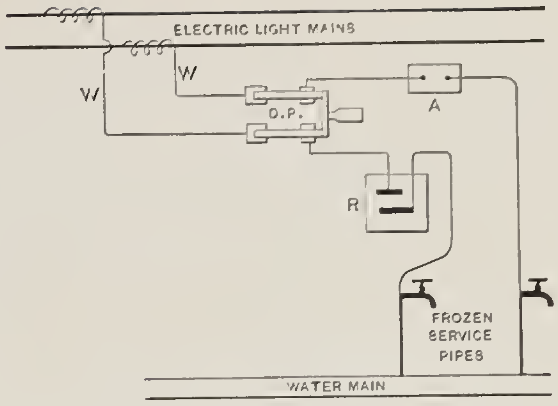


FIG. 5.—CONNECTIONS FROM A DIRECT-CURRENT OVERHEAD LIGHTING SYSTEM

is generally essential to avoid short-circuiting the electric mains and to prevent possible injury to the water pipes from a too prolonged application of the current.

Although the tapping of overhead electric light and power circuits for the purpose of thawing out frozen water pipes has been carried on extensively and successfully for several years past, this procedure obviously possesses certain limitations, as already stated, namely, that the area in which the current can be so used is restricted to the locality of the overhead circuits.

In such cases, however, other ways of obtaining the necessary electric current are available; for example, by means of a portable storage battery or a dynamo driven by a gas engine, both of which sources of electromotive force, mounted on wagons drawn by horses, have been utilized and will doubtless, when necessary, be much more extensively used in the future for this particular class of work.

The electric light and power companies will probably still retain the bulk of the business by reason of the fact that in ordinary winters the amount of the business of this kind would not warrant the maintenance by private individuals of the requisite independent outfit. To furnish an idea of the revenue derivable from this source in some places, it may be noted that in one city alone an amount approximating $7000 was turned into one lighting company by the water-

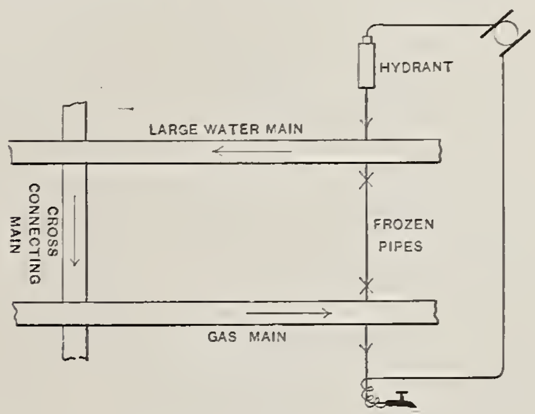


FIG. 6.—A CASE OF CROSS CONNECTION

pipe-thawing department during the past winter.

In a recorded instance in which the storage battery has been thus employed, the cells were carried on a wagon and were arranged for heavy-current work, the connections being such that the cells could be thrown on in series or in multiple for high voltage and small current, or vice versa, as desired. The heavy current and low voltage were employed for large pipes or mains, and the reverse for small pipes, the voltage used varying from 6 volts and over 800 amperes to 15 volts and 300 amperes. In the first case a small water main about 20 feet long was involved and water flowed in about three minutes after the application of the current.

For a portable gas-engine-driven dynamo outfit, a generator of about 8 or 10 K. W., delivering say 600 amperes at 12 or 15 volts will suffice for the work under consideration. The engine ought to be of 12 to 15 H. P. The connections for such an outfit are practically as outlined in Fig. 2, the leads *W W* being, however, connected to the brushes of the dynamo.

Still another portable arrangement that has been used for the thawing out of frozen water service pipes, is one in which a 12-H. P. gasoline automobile was drafted into the service, a dynamo of about 7 K. W. developing 600 amperes at 12 volts, being mounted on the front part of the vehicle. In this case, the gas engine is employed to propel the vehicle to the desired point, and a belt is carried to the dynamo pulley from the same engine. In one instance in which this outfit was employed, the water came in forty-six seconds after the application of the current. This outfit has the advantage that horses are dispensed with, while it retains all the mobility of the horse-drawn vehicle.

Some further data as to the character of the pipes thawed out by the electrical process, and the time taken in actual practice for the operation may now be given. In the case of a length of about 45 feet of 1-inch pipe, in which one terminal of the current was connected to the city hydrant and the other to the faucet within the building, with a direct current of 140 amperes, at a pressure of 220 volts, the water flowed in seventeen minutes. In another instance 100 feet of 1-inch pipe were thawed out after an application of a current of 175 amperes for about fifteen minutes.

In one city in which a great many water service pipes have been electrically thawed out during the past winter, the average time of application of alternating current of 100 to 150 amperes at 60 volts, was about three minutes. In many cases the water flowed within one minute. When the water did not flow within twenty-minutes the attempt to thaw the pipes in this manner was given up, the contracts for the work providing that there would be no charge unless the water was forthcoming.

For this reason, doubtless, the same workers had no success in thawing out frozen fire hydrants; for in another city an application of 90 amperes at 50 volts for fifty minutes produced a flow of water from two adjoining fire hydrants that had been frozen up for some days. It is, in fact, probable that a sufficiently long application of the electric current in sufficient quantity will produce the desired effect in almost every case of frozen water pipe or hydrant, unless perhaps when the frozen pipes are, so to speak, bridged or shunted by much larger mains. Such cases have been met with in practice.

An instance of this condition is illustrated in Fig. 6, in which the service pipes were frozen between the water mains and a gas main, on opposite sides of the street, the mains being cross-connected by a large main at a nearby point. In this case the water pipes within the house were heated to a high degree, but the water did not come, proving that a short circuit of the pipe existed.

In other instances in which the current could not be forced through the service pipes it was assumed that the joints connecting the mains were insulated by means of some non-metallic substance. In still other cases the attempt was unwittingly made to thaw out service pipes which were connected to earthenware mains.

In the case of a water main 4 inches in diameter, about 110 feet of which were frozen, a 10-volt alternating current of 150 amperes brought a flow of water after a 6-hour application of the current. In still another instance in which 80 feet of $\frac{5}{8}$-inch lead pipe connected to 20 feet of 6-inch iron pipe were involved, an alternating current of 185 amperes at 35 volts brought water in about fifteen minutes.

Frozen gas service pipes have also been successfully treated by the electrical process, but usually the time of application of the current is longer than in the case of water pipes.

In all of the foregoing instances the connections were made at the most accessible points, as at fire hydrants, water faucets and the like. When the mains are frozen in places at which the pipes do not come to the surface at two near-by points, it is then necessary to dig down to the pipes to make suitable connections with them.

While it is a well-known fact that the freezing of exposed service pipes in buildings is almost invariably followed by the bursting of the pipes by the expansive force of the freezing water, it has been observed in connection with the work of thawing out the service pipes that a case of bursting pipes in the earth is very rare—less than one in 600, according to the writer's best information. This is assumed to be due to the fact that the earth first freezes rigidly around the pipes, exerting a counter pressure on the outside of the pipes, thereby preventing them from giving way to the internal pressure.

In thawing out pipes by the electrical proccess, the ice in the pipe first melts close to the metal, allowing the water to flow through in small quantities at first, but this is soon followed by the full flow of water. In some cities the first flow of water is accompanied quite often by a large amount of muddy water and solid pieces of sediment, as though the freezing had loosened the scale on the pipes. This has led some one to suggest that artificial freezing and thawing of the pipes might afford an economical and efficient method of scouring out service pipes.

As previously remarked, care must be taken not to apply the current long enough to unduly heat the pipes. So far as the writer is aware, no case of overheating has thus far occured in practice, the ice and the cold water apparently sufficing to keep down the temperature of the lead or iron pipes. Temperatures of 100 degrees F. have been observed on pipes thus treated, but this is still far below the melting point of lead—617 degrees F.

A Sleeping Car on an Electric Railway

THE Columbus, Newark & Zanesville Traction Company, operating an electric road between Columbus and Zanesville, in Ohio, a distance of about 55 miles, has placed in service recently a sleeping car with berths for twenty persons. During the day the car will accommodate twenty-four passengers, the seats being swivel chairs, two of which combined make a berth, wooden shutters being brought up from the floor to divide the car into compartments.

European inspectors take snapshots of men engaged on public work. The photos in some cases are more eloquent than any report could be. One showed a group of thirty men on a road paving job. Two of the thirty were at work.

The Handling of Freight by Electric Roads

By LEMUEL WM. SERRELL, M.E.

A Paper Read at the Recent Utica (N. Y.) Meeting of the New York State Railway Association

THE primary object in the construction of railroads is to move both passengers and freight from place to place, landing the passengers as near as possible to the place at which they wish to alight and delivering freight and express matter at their destinations.

The development of the electric railroad has been very rapid. In the early part of 1888, only 86 miles of electric railroad with about 172 cars, were in operation in the United States. The census report for June 30, 1902, shows 22,589 miles of electric railroads, using 67,199 cars, and requiring 1,298,133 H. P. for their operation. The total number of passengers carried during that year was nearly 6,000,000,000, with gross earnings of almost $242,000,000. This enormous development has taken place principally in the picking up and dropping of passengers along highways, but the electric railroad has for some time passed from a city road and is to-day in practical competition with the steam railroads, operating its cars at a high speed over private right of way between cities. The day is not far distant when Albany and Chicago will be thus connected with trolley railroads.

During most of the time in which this development has been taking place, the idea of carrying freight has received scant attention, as the energies of electric railroad managers have been taxed to the utmost to successfully handle the crowds of short-distance passengers. In many places, however, the municipalities have had an idea that possibly this development would in time lead to the carrying of freight through their streets, and they have given franchises prohibiting such uses of the highway; but with the development of the interurban road operating largely on private right of way, even such restrictions cannot altogether prevent the profitable handling of interurban freight.

The possibilities of freight business are now so generally recognized that it is seldom promoters present a prospectus for a new electric road which does not include large estimated freight receipts, usually, however, much in excess of what the roads will actually earn.

In order to successfully handle freight, it must be carried to its destination, which is usually its market. Up to the present time electric railroad companies have been practically limited in the amount of freight handled to that which is produced and consumed along its own line of road.

Some idea of the amount of this business may be gathered from what follows.

In New York State for the year ending June 30, 1903 we find the following:—

	Freight and Express	Car-Miles	Receipts per Car-Mile
Albany	$37,936	49,797	75c.
Rochester	28,381	46,764	60c.
Newburgh	12,881	16,516	78c.
Hudson Valley	22,190	54,842	40c.
Brooklyn Heights	75,658	189,494	40c.
Buffalo	89,354	219,672	41c.

It will be noted from the above that the freight receipts per car mile are large.

The freight business on electric roads in the Eastern West has been developed more than in any section of the country.

For the year ending April 20, 1903, the writer has been able to secure the following information for Ohio:—

	Freight	Express	Total
Eastern Ohio Traction	$44,000	......	$44,000
Toledo & Western	23,000	......	23,000
Cincinnati, Georgetown & Portsmouth	37,500	$10,200	47,700
Cleveland & Southwest'n.	10,000	7,200	17,200
Lake Shore Electric	26,200	4,700	30,900

No details are obtainable as to car mileage or cost of operation.

No information is published that is absolutely reliable for Pennsylvania, though the following roads report incomes from other sources than passenger for the year ending June 30, 1903:—

Altoona & Logan Valley	$29,562
Lancaster	22,305
Harrisburg Traction	40,411
Lehigh Valley Traction	34,193

It is probable that these figures are largely made up of freight and express receipts.

An examination of reports of thirteen Pennsylvania steam railroads, averaging in length from 10 to 30 miles, with steam railroad connections and facilities for shipment without transfer from cars, shows the average gross freight earnings per mile of track per annum to be $2,270. Of this amount two-thirds are the product of mines, and one-third, or about $750 per mile per annum, is made up of the products of agriculture and the forest, meat and live stock, merchandise, manufacturing products and miscellaneous freight.

Statistics place the average gross freight receipts of steam railroads at $650 per mile of track per annum, the average gross receipts of thirty-seven roads of the Middle West being given at $27,000 per road per annum.

In some sections of New York State, the following are the average yield of agricultural products in tons per acre:—Hay, 1½ tons; wheat, ½ ton; barley, 1 ton; oats, 0.6 ton; buckwheat, 1 ton.

The amount of milk produced varies considerably with different sections of the country, although usually the suburbs of large cities are quite large producers of milk, on account of the city demand. The writer has figures that show about 6500 gallons of milk per square mile per annum for such localities.

It is almost useless for electric railroads to hope to handle coal until steam railroads are willing to entrust their cars laden with coal to the electric roads for delivery. The best figures that the writer has been able to obtain show that there is consumed for household purposes, about 2 tons of coal per capita per annum.

It is not the purpose of this article to deal with the question of freight rates, nor with the methods of billing freight and the books of account, but simply to discuss the freight business that can be secured under present conditions, and point out some methods, the adoption of which would probably lead to large increases in receipts from this source.

It has already been stated that the freight business now done on electric railroads is confined very largely to the freight produced and consumed along the line of each individual road. This, of course, includes a small percentage of freight originally shipped on the line of some steam road and consigned to some station on the line

ELECTRICITY BUILDING AT THE ST. LOUIS EXPOSITION WAS SPECIALLY ILLUMINATED ON THE EVENING OF ELECTRICAL DAY, SEPTEMBER 14

of an electric road, the freight being broken from the bulk and taken by the electric road to its destination.

There seems to be a settled policy among steam railroads of declining to do business with electric roads under any form of traffic agreement. To illustrate this point, some time ago the Delaware & Hudson Railroad posted notices in all of their stations instructing agents not to receive freight consigned to any point on the Oneonta, Cooperstown & Richfield Springs Electric Railroad. The Lehigh Valley positively refused recently to enter into any traffic agreement with a certain electric railroad to receive from or deliver to it any freight, even though by so doing they would have secured from the electric road a terminus in a city of over 100,000 population. They likewise declined to allow the electric railroad to sell tickets from this city to any point on their road, or to sell tickets themselves from any of their own stations over the electric railroad to the large city in question.

The Delaware, Lackawanna & Western Railroad have recently been fighting in the courts to prevent an electric railroad laying a switch from the middle of the highway to connect with their tracks for facilitating freight handling.

One might wonder why steam railroads thus oppose connection with electric roads that would result in a profitable business to them. The answer is probably that the majority of steam railroads are banded together through traffic associations to maintain freight rates and prevent traffic wars. These associations exist throughout different sections of the country, and each association is made up of the traffic managers of steam railroads belonging to the association. It is possible that the proceedings of these associations are secret and that they are guided by unwritten laws. However, at the present time, the associations are accomplishing good results in maintaining rates. There seems to be an understanding that the members of the associations will not invade new territory other than that already occupied, and the probabilities are that any member of such an association entering into a traffic agreement with any electric railroad to receive from them or to deliver to them freight in bulk, shipping it through on one bill of lading from shipping point to destination, would subject itself to a freight war at some other more important point. This is doubtless the reason why steam railroads do not dare to make any traffic agreement with electric railroads that would result in a profitable and increased business to both.

The writer has recently received official figures regarding the freight business done on an electric railroad 37 miles long, which formerly was operated by steam, and which was a member of certain traffic associations and thus received and delivered freight on one through bill of lading in the original cars. Since the equipment of this road and its operation by electricity, the management have been unable to make any arrangement for freight charges pro rata, but have operated with the advantage of through shipments in their favor, each railroad charging its own rate. The business done this last year under these conditions was as follows:—

Freight	$32,000
Express	5,500
Milk	3,000
Total	$40,500

This is practically $1100 gross per mile of track per annum, which is half as much again as most electric railroads are able to earn operating without this advantage. The express receipts are large, owing to the fact that an arrangement is made with the American Express Company, who do business on the electric road as on any steam road.

During the past few years a number of steam railroads have purchased electric railroads paralleling their own tracks. It has generally been the impression that these purchases have been made so that the steam railroads might control important links that would prevent the formation of a large system of competing electric roads; but doubtless the steam railroad people whose business consists largely in handling freight have appreciated the possibility of a traffic organization similar to their own being formed among the electric railroads by which freight could be handled and distributed over a large section of country—a greater menace to their business than simply controlling some important link to prevent through passenger traffic.

It is the writer's belief that this possibility has not before been brought home to the managers and owners of the electric properties that exist to-day. Suppose, for example, a traffic association was formed, having as its members all of the electric railroads that will shortly reach from Albany to Chicago, the object of this association being to ship freight over the electric road lines, without breaking bulk, to any points in the territory covered by them. Such an association, properly organized and fostered, would result in far more dangerous competition to steam railroads than any through passenger business that can ever be built up. And it seems possible that in the purchase of important electric links by steam railroad corporations they have had in mind the prevention of this development more than anything else.

Judging from the investigations covering a number of individual cases which the writer has made regarding the amount of freight now handled by electric railroads, the amount of this business under present conditions, except in unusual cases, will not exceed $750 gross per mile of track per annum, and it is the writer's belief that the time has now come to organize a freight traffic association among the electric railroads now operated, for the purpose of establishing an interchange of freight and broader markets for it, and that the establishment of such an association is necessary if the electric railroads would hope to largely increase their present freight business.

Electricity Day at the St. Louis Exposition

By CLOYD MARSHALL

During the session of the International Electrical Congress at St. Louis from September 12 to September 17, and while the electrical juries were at the Exposition, Electricity Day was celebrated. The occasion was notable on account of the elaborate decoration of the Electricity Building, the special illumination and the grand reception in the evening given to the International Electrical Congress. All the exhibitors decorated their spaces with flags and bunting, and in many cases, festoons of lights added much to the beautiful interior lighting effects. Many of the companies sent their officers and electrical engineers to set forth the merits of the machinery and apparatus exhibited. All the exhibits were in full operation, which made the building a center of attraction to the large crowd on the grounds. During the day and evening 16,084 visitors called at the booth of the American Telegraph & Telephone Company, and many of the other exhibits received quite as much attention.

In the morning a joint meeting was

held in Festival Hall of the International Electrical Congress with the Institution of Electrical Engineers of England and the American Institute of Electrical Engineers. At noon the Engineers' Club, of St. Louis, gave a luncheon to the members of the Congress in the main corridor of the Electricity Building. Immediately afterwards the Electricity Day parade was formed at the north entrance of the building. This was headed by a company of Jefferson guards, followed by automobiles carrying the members of the Electrical Congress.

In the afternoon occurred the formal opening of the De Forest long-distance wireless communication between the World's Fair Grounds, St. Louis, and Chicago. This is the longest overland distance yet covered, and is made more remarkable from the fact that the Chicago station is on the North Shore, completely screened by the many miles of steel-framed structures in that city, lying between it and St. Louis. The test took place at a time when the Jury of Awards was investigating the merits of the De Forest system. The jury appreciated fully the significance of this important advance, and lent dignity and authority to the demonstration by sending two of their number, Mr. Wm. J. Hammer, chairman of the Jury of Telegraph and Telephony, and Professor James C. Kelsey, to Chicago to witness the receipt of messages. President Francis and other officials, as well as distinguished members of the International Electrical Congress, were present at the World's Fair station. The Jury had control of the demonstration for two hours, and sent a number of test and code messages to their fellows in Chicago. The preliminary message read: "Regards to Hammer and Kelsey by wireless."

Inasmuch as the Chicago station was not then equipped with powerful transmitting apparatus, long-distance telephone communication was maintained between the two stations throughout the afternoon. The first wireless message was instantly received by Mr. Hammer, of the jury, at Chicago. The following sealed message was then opened and at once transmitted to Chicago: "The names of Faraday, Hertz, Branley, Depoff, Lodge, Muirhead, Marconi, De Forest, Edison, Tessla, Braun, Fessenden, Sliby, Arco, Rochefort and Shoemaker are among those names indissolubly connected with the principles and the application of wireless telegraphy." This message was sent twice, the second time with the word "indissolubly" purposely omitted, and was received both times in Chicago exactly as transmitted. Several other code messages were sent, and the jurors of Chicago listened to the signals themselves, which, they said, came in remarkably strong. Professor Kelsey stated that if the station had been at Minneapolis instead of Chicago, signals could have still been read. At the conclusion of the jury's test, Professor Goldsborough, at their request, made the following formal announcement before the assemblage:—

"St. Louis, Mo.,
Electricity Day,
"Gentlemen: Sept. 14, 1904.

"I have the honor to announce that the jurors report that every message sent from St. Louis has been received in Chicago with perfect accuracy. I heartily congratulate Dr. De Forest and his co-workers.

(Signed) W. E. Goldsborough."

In the evening the Electricity Building was open to those having special invitations and wearing Congress badges. Guests were received by President Francis, Professor W. E. Goldsborough and other prominent members of the Congress. Refreshments were served on the south balcony facing the cascades, and the dancing floor was the main corridor of the building. Music was furnished throughout the day and evening by several bands in the court and on the balconies of the building. The approach to the lagoons from the south-east entrance of the building was roped off so as to give free access to the gondolas and launches which were at the disposal of the guests.

The launches were beautifully decorated with incandescent, Nernst and Cooper Hewitt lamps. One of the launches had the mercury vapor tube so arranged as to form the letters "L. P. E." Early in the evening these launches manœvered in the grand basin in a manner to display their illumination to the best advantage. In the grand basin were six fantastically formed floats, beautifully decorated with evergreen and illuminated by incandescent and Nernst lamps. The trees adjoining the grand basin were festooned with colored lamps, and from the cornice of the building to the trees were great streamers of lights over the roadways. On top of the building were mounted three of the most powerful search-lights made for the Italian Navy. In order to get these here in time for Electricity Day, Salmoiragi, Stucci & Company, of Turin, sent them by express. The beams from these lights were the most powerful and beautiful of any on the Exposition Grounds. The splendid general effect of the illumination may be seen by the excellent photographic reproduction on page 358, showing the Palace of Electricity and its surroundings.

Perhaps the most novel spectacle of all was the discharges from the megavolt transformer, which is the highest potential, low-frequency transformer yet constructed. It is of 100 K. W. capacity, 25 cycles and designed for 1,000,000 volts, but no effort has been made to accurately determine the potential of the secondary. The transformer was designed and constructed by C. H. Thordardson for Purdue University, where it will be sent at the close of the Exposition. A line extends from the secondary of the transformer along the front of the building, with the spark gap at the bridge in front of the main entrance. The terminals consist of two 1-inch brass tubes placed vertically, but slightly diverging at the top, the gap being between 2 to 3 feet. The discharge is accompanied by a beautiful flaming arc and loud cracking sound which is similar to a "pom-pom" in action. When the aerial lines are subject to the high voltage, they glow with phosphorescent light. These demonstrations were given in the evenings, and proved of great interest to the visiting engineers. The whole week of the International Congress and the electrical conventions was a great success, and Electricity Day was the crowning feature.

Municipal ownership of street railways was the question voted on at a recent meeting of the City Council, of Chicago. The immediate question was as to whether the matter should be submitted to the people at the November election for their decision, but the motion was defeated by a vote of 36 to 31.

The amount of moisture present in an air-dried sample of coal is an indication of its liability to heat, the danger increasing with the percentage of moisture contained. Coal containing over 4.75 per cent. after air-drying is said to be dangerous.

The Canadian Westinghouse Company, Limited, of Hamilton, Canada, have opened offices in Winnipeg, Manitoba. The offices are located in the Union Bank Building. The representative in charge of the district covered by this office is Mr. W. E. Skinner, who was formerly associated with the Westinghouse Electric & Manufacturing Company, of Pittsburg, Pa.

The Commercial Development of Water Power

By ALTON D. ADAMS

UNDEVELOPED water power is sometimes regarded like a rich gold mine, that is, as a property that has only to be worked in order to yield large profits. Nothing could be further from the facts in some cases. The mere circumstance that a stream with a considerable volume of water flows between high banks for some miles, so that it may be readily dammed up, or that it plunges over a rather high fall, does not necessarily give it any value whatever for power purposes. In other words, engineering practicability is no sufficient test of commercial expediency in the development of water power.

For the successful development of water power from the financial point of view, it is a prime necessity that there be population by which, or industries in which, the energy can be utilised. The next important question relates to the cost of the development and the income that can be obtained by the sale of power. Both of these matters depend to a large extent on the constancy of the power, and on its minimum rather than on its maximum volume. It might seem superfluous to call attention to these fundamental facts were they not so often lost sight of by promoters of water power development, and even in some cases by engineers who are called on to advise in such matters. Electrical transmission and distribution have done much to make practicable the development of unused water powers, but transmission of power in any save very large units soon finds commercial limits, and distribution can supply, but cannot create, consumers.

An interesting illustration of these principles recently came to light in the investigation of a proposed development of water power for electrical supply, and the main facts of the case are given below, save that all names which might serve to identify the power site are omitted.

The site in question is located in the western half of the United States, in an agricultural and stock raising section, and is several hundred miles from any city of considerable size. A river that has cut for itself a gorge of 60 to more than 100 feet in depth through the soft rock of its bed, and of varying width, for a length of several miles, is the proposed source of the water power. Where the steep sides of the river gorge approach each other to within a distance of about 200 feet, it was proposed to erect a masonry dam with a height of nearly 60 feet above bedrock, from bank to bank. By this dam a reservoir more than 5 miles long would be created, and a head of 50 feet of water would be made effective for the wheels.

Near one end of this dam an electric generating station was to be located and the energy there developed by the water was to be distributed in two settlements not more than 5 miles apart, and lying on opposite sides of the water power site. It was thought that the entire flow of the river, with an effective head of 50 feet at the wheels, would enable the delivery of 4000 H. P. regularly for twenty-four hours per day, and that in the driest times this output need never drop much below 3000 H. P.

This power was to be sold in the two settlements already mentioned, each of which has a population of about 1000 persons. One of these settlements is located on the only railway line in that part of the country, and is a trade centre for the territory to a distance of 100 miles round about. As the two settlements mentioned, when taken together, have a population larger than any place within nearly 200 miles, there seemed to be no opportunity for profitable transmission of the power to distant points.

One of the first steps in the investigation of this problem was to determine the volume of water and consequently the power that would be available at different times of the year. Fortunately the daily discharge of the river, in cubic feet per second, had been recorded during several years for a point a little above the site of the proposed dam. From these records for a recent year it appeared that the minimum rate of discharge on the days of nine months was not less than 600 cubic feet per second, taking averages of two days together. In these months the maximum discharge never fell below 750 feet per second, and in two of them it rose to more than 1500 per second. During the remaining three months of the year the records were mostly lacking because of ice in the river.

A survey of the power site and of the river above showed that the reservoir formed by the dam would extend up stream more than 5 miles, would have an area of nearly 1 square mile, and would contain about 7000 acre-feet of water. For the nine recorded months of the year in question, the lowest monthly discharge of the river was more than 38,000 acre-feet, and the highest was less than 54,000 acre-feet. This uniformity of discharge seemed to be due to the fact that the river flows through a sandy country and is supplied mainly by springs. It should be noted that the storage capacity of the reservoir behind the dam would equal nearly one-fifth of the minimum monthly discharge of the river. On the foregoing facts it seemed that the minimum discharge of water available for power production might safely be taken at 600 cubic feet per second throughout the entire year.

With this discharge of water under an effective head of 50 feet, its rate of work would be represented by $(600 \times 62 \times 50) \div 550 = 3380$ H.P. Fair efficiencies for water wheels, electric generators, distribution lines and transformers, at full load, may be taken at 74, 93, 92 and 95 per cent., respectively. On the basis of these figures the electric system would deliver to consumers $0.74 \times 0.93 \times 0.92 \times 0.95$, or fully 60 per cent. of the total energy of the falling water, and this would amount to $3380 \times 0.60 = 2028$ H. P., or almost exactly 1500 K. W. This power, it is to be noted, represents a large reduction from the 3000 to 4000 H. P. which it was thought the river might furnish. If operated continuously throughout the year for twenty-four hours per day, the minimum discharge of the river would yield $1500 \times 8760 = 13{,}140{,}000$ kilowatt-hours for the use of consumers on the electric lines.

With a population of only 2000 to be served, it would thus be necessary that each should consume $13{,}140{,}000 \div 2000 = 6570$ kilowatt-hours on an average, in order that the continuous output of the plant might be sold. That such a rate of consumption would be most unusual was seen by comparison with the numbers of kilowatt-hours sold per inhabitant on an average in several cities during past

years. In one city, where there is a large and prosperous electric system operated mainly by water power, the average amount of electrical energy sold per person in the population, as determined by the census of 1900, was 107 kilowatt-hours, during 1901. This energy was absorbed by a large lighting load, and stationary motors of more than 3000 H. P. rated capacity, besides a relatively small amount of electric heating apparatus.

Another city, where most of the energy distributed by the electrical supply system comes from water power, used 158 kilowatt-hours on an average per inhabitant, in 1903, on the basis of its population in 1900. In this city the load of stationary motors had a rating of nearly 3000 H. P., and there was a large lighting load, but comparatively little electric heating. Neither of these cases includes the energy used by the local electric car lines.

From these illustrations it was at once evident that 13,140,000 kilowatt-hours per year could be sold to a population of 2000 persons only under some extraordinary conditions. Such conditions, it was thought, might be found in the offer of electric energy at very low rates in a place where soft coal of only moderate quality sells for $8 per ton, and where ordinary kerosene for lamps costs 25 cents per gallon. These are the current prices for the commodities named in the places where the electric energy from the water power was to be sold.

It appeared on investigation that the population of 2000 persons consumed annually more than 7000 tons of the soft coal at a cost of more than $56,000 and approximately 30,000 gallons of kerosene, costing nearly $7500. A very large electric load in proportion to the population might be obtained, it was thought, by making the rates for light, heat and power as low as the cost of coal and oil for corresponding results.

The conclusion reached as to lighting was that at the rate of 3 cents per killowatt-hour the number of these units that could be sold per year for lighting would reach 150,000. From this source the probable income was thus 150,000 × 0.03 = $4500 annually. Stationary motors it seemed would absorb as much as 300,000 kilowatt-hours per year if the rate for power service was also put at 3 cents per unit, and the resulting income would be 300,000 × 0.03 = $9000. An electric railway from the depot to the settlement, about 4 miles distant, over which there would be a large freight as well as passenger traffic, was estimated to consume fully 200,000 kilowatt-hours yearly at a rate of 2 cents, so as to yield an income of 200,000 × 0.02 = $4000 to the electric supply system.

On these estimates these three lines of service, that is, lighting, stationary motors and electric railway, would give the supply system an income of $17,500, and would consume only 650,000 kilowatt-hours of its energy per annum. As the possible output of the proposed plant when working continuously at the rate of 1500 K. W., on an average, was 13,140,000 kilowatt-hours yearly, the lines of service just considered left 12,490,000 kilowatt-hours of this output unsold.

Electric heating was thus the only service to which the great bulk of the energy from the proposed plant could be devoted. One pound of only moderately good soft coal contains about 12,000 latent heat units, but hardly more than 6000 of these units are usually made available for warming and cooking, because of imperfect combustion and the losses due to high temperature of flue gases. On this basis a ton of 2000 pounds yields 12,000,000 units of heat for useful purposes. As a kilowatt-hour is the equivalent of 3412 heat units, all of which are available at an electric heater in warming or cooking, it seems that 12,000,000 ÷ 3412 = 3517 kilowatt-hours will equal 1 ton of this coal in useful heating effect. The entire yearly output of the plant would thus do the work in heating of 13,140,000 ÷ 3517 = 3736 tons of coal, or about one-half of the amount consumed by the population to be served. There was, therefore, an ample market for the electric heat if it could be sold at a rate that would displace coal.

It was found that during the month of July, 1903, the consumption of coal was not less than 250 tons, or about 670 pounds per hour for the twenty-four hours of each day on an average. This rate of coal consumption would yield 4,020,000 heat units per hour, on the basis of 6000 units per pound. If carried by the electric system, the heating load thus presented even in July would represent a continuous output of 4,020,000 ÷ 3412, or 1178 kilowatts.

As 1 ton of the coal in question, costing $8, equals 3517 kilowatt-hours in useful heating effect, the electrical energy must be sold at 800 ÷ 3517, or 0.22 cent per kilowatt-hour in order to just equal the bare full cost of the heat from coal. To make the electric heat slightly cheaper than the bare cost of coal for an equal effect, the rate may be put at 0.2 cent per kilowatt-hour, so that the output of the plant may all be sold. As shown above, after all of the probable demand for light and power has been supplied, there will remain more than 12,000,000 kilowatt-hours of the possible yearly output that may be sold for heating. On the rate for heating just mentioned, the annual revenue from this output would amount to 12,000,000 × 0.002 = $24,000. Combining with this sum the estimated earnings from the supply of light and power, it seems that the annual income of the electric supply system would amount to $41,500 if its entire output were sold.

In order that the electric station may yield a continuous output of 1500 kilowatts for consumers, on an average, its generator capacity should be at least 2000 kilowatts, so that machines may be shut down for inspection and repairs, and so that a maximum load of more than 1500 kilowatts may be carried. The dam of more than 200 feet in length and nearly 60 feet high above the bedrock should be of cement concrete, and so also should the foundations for the power stations.

Above its foundations the power station should be constructed entirely of brick, slate and steel, save at the doors and windows, and its height should be one story. The location of this station close to one end of the dam will cut the cost of penstocks and hydraulic work to the lowest figure consistent with first-class construction. Distribution lines for the electric system were designed to be entirely overhead, and to be connected with transformers and meters for the delivery of the output of 1500 K. W. to consumers. Owing to the fact that 80 per cent. of this energy was to be used for heating, the cost of distribution lines was found to be somewhat below that which would be necessary with a light and power load. To construct the above dam and generating station with complete equipment, and to build and supply with transformers and meters the distribution system, the total cost was estimated at $450,000.

Comparing this cost of construction with the $41,000 of estimated annual earnings for the electric system it seems that the latter amounts to only 9.1 per cent. of the former. In a system like the one under consideration, where all the electric energy is developed by water power, and most of it is sold for heating, the expense of operation will be comparatively low. Even with this advantage, however, it is very evident that operating expenses, interest and depreciation, to say nothing of profits or dividends, cannot be paid out of a gross earning that amounts to only 9.1 per cent. annually on the investment.

Having found that the plans of the promoters of the above plant could not be carried out at a profit, it re-

mained to be seen what could be done on a sound financial basis. A little consideration was sufficient to show that an electric plant under the circumstances of this case could not hope to show a good return on its cost so long as the greater part of its income was derived from heating in competition with coal at $8 per ton. The next step was to reduce the capacity of the entire plant to a point where light and electric motive power would become the more important loads. In order to provide for all the light and power service that would probably be required for many years to come, it was decided to give the dam a height that would maintain an effective head of 20 feet of water on the wheels instead of 50 feet, as had been proposed.

With this head the minimum rate of discharge in the river and the efficiency of 60 per cent. between the power of the water and distribution system, there would be a constant output of 600 K. W. available for consumers. At present most of this output could be sold only for heating, but as the demand for light and power increases, some of the heating can be omitted. Twenty feet was fixed on for the head of water because lower heads cost more to develop and because it is much more economical to give a dam its maximum height at first than to increase the height and thickness after a plant is in operation. Moreover, the head of water fixes both the power and speed of the wheels and consequently the frequency, capacity and voltage of their direct-connected generators, so that any considerable change in the working head after a plant is in operation requires expensive changes in electric generators and transformers.

With a constant load, on an average, of 60 K. W., the output of the electric station would reach 5,256,000 kilowatt-hours annually. As shown above, 650,000 kilowatt-hours could probably be sold per year for light and power purposes at once. This would leave 4,600,000 kilowatt-hours to be sold for warming and cooking, instead of the 12,000,000 kilowatt-hours that would be offered for these purposes from the larger plant. Because of its limited quantity this smaller amount of energy could probably be sold for 0.3 cent per kilowatt-hour, which would make its heat 1.5 times as expensive as that from coal. The income from heating and cooking on this basis would amount to $4,600,000 \times 0.003 = \$13,800$ annually. The addition of this sum to the $17,500 to be derived from the light and power service raises the probable gross earnings of the 800-K. W. system to $31,300 annually. From year to year the demand for light and power will increase and the price for energy used in heating can be gradually raised, so that the gross and net income would grow larger because of both more business and higher prices.

To construct the dam for a water head of 20 feet, build and completely equip the electric generating station for a maximum output of 800 K. W., and erect a distribution system with transformers and meters for the delivery of 600 K. W. regularly to consumers, was estimated to cost $170,000 in condition to operate. Of this sum the probable annual earnings of $31,300 in sight at the start form 18.4 per cent. of the investment. Such a percentage of the earnings to investment would hardly be satisfactory as a permanent matter, but in the case under consideration, it seemed advisable to make the hydraulic development great enough for all future demands. Having done this it was better to install the generating and distributing apparatus and sell the surplus energy for electric heating than to let the water go idly over the dam.

Had present requirements alone been considered, the height of the dam would have been designed for a head of 10 or 12 feet, and a generating station and distributing system of about 300 K. W. capacity would have been constructed. Such a plant could have been enlarged at some later date only with a relatively great expense.

The chief value of this illustration from actual practice is that it shows some of the conditions that are met and some of the considerations that govern in the development of water powers for electrical supply.

A New Electric Railroad in Peru

ACCORDING to a recent consular report, the electric railroad between Lima and Callao, the second enterprise of its kind in Peru, is in operation. Like its predecessor, that between Lima, Chorillos, and other near-by seaside resorts, the Lima-Callao road is equipped with American power machinery and handsome American cars, both open and closed. The roadbed and track were laid by an American firm.

The new road, which is run by the overhead trolley system, covers the 8.6 miles between Lima and Callao in a little over twenty minutes. It runs cars every fifteen minutes and has lowered by one-half the fares formerly existing on the steam railroad. The new railroad has thus far been unable to obtain permission to run through the principal streets of Lima, and therefore stops at Union street (the chief commercial artery), where it connects with the city horse cars; but it is believed that the obstacles to electric traction through the streets of Lima will soon be removed. The road runs through the main streets of Callao, and has, besides, a prolongation of about a mile and a half to La Punta, a seaside resort a short distance farther down the coast.

The new road is remarkably popular and is so much traveled as to make the acquisition of additional rolling stock a necessity. It fills a long-felt want of frequent and cheap communication between the capital city and its port, which, although a separate municipality, is and has for many years been a commercial suburb of Lima.

Zone Fares on British Electric Railways

COINCIDENT with the electrification of some of the steam railroads of Great Britain, says "The Electrical Times," of London, the system of zone fares, or fares proportional to certain distances, is being instituted on the lines electrified. This has already been done on the Lancashire & Yorkshire Railway and on the North Eastern Railway.

The Metropolitan District Railway is also considering this system, and will probably introduce it when the lines are electrified. Zone fares are charged on some of the lines of the Great Central Railway, and have given encouraging results. The Caledonian Railway Company, which has suffered considerably from the competition of the Glasgow tramways, has also adopted the zone system of fares on some of its suburban lines, and purpose extending the system.

It is reported from St. Paul, Minn., that the Northern Pacific Railroad Company is preparing to place the telephone in general use on its system for the transaction of the railroad business and for the operation of trains. During the last two years the company has subjected the telephone to severe use for the purpose of making a complete test in several places, with such success that it has now been decided to use the telephone for the main line between St. Paul and Portland, Ore.. The telegraph will also be used as a secondary means of communication.

The total horse-power developed by the two Niagara power companies who alone at present are utilizing Niagara's power, amounts to 115,000.

Long-Distance Power Transmission

Its Economic and Engineering Aspects

By CHARLES F. SCOTT

Reprinted from the "Electric Power Number" of Cassier's Magazine

LONG-DISTANCE transmission of power may be considered from any one of several points of view. Considering it from its economic aspect, one who has not given particular thought to the subject will be astonished to find, on analysis, to how great an extent the operations of modern life depend upon the mechanical power. Its importance is most forcibly realized when the supply of power is cut off by a coal famine. Railways, steamships, tramcars, mills, factories, electric lights, all are brought to a standstill, and the production of ice in summer as well as heat in winter is interrupted. Any agent which enables power to be transmitted over long distances, so that water-power, which would otherwise be of little or no consequence, is rendered of immediate and practical value, brings into commission a new source of power. This may be of little moment where fuel is abundant, but it is of vital importance where fuel is scarce and water-power is available within a practicable radius.

Electric transmission not only makes available a new source of power, but it insures in its distribution those advantages, notably flexibility and ease of application, which are incident to the electric motor. Electric transmission and distribution, therefore, take a very important place in the general economic problem of supplying cheap and abundant power, upon which modern industry and commerce and social life have come to depend so vitally.

Power transmission may be viewed also from the financial standpoint. The transmission plant may be considered as an investment of which the value is dependent entirely upon the financial returns. From such a standpoint it is immaterial what becomes of the power; it may be devoted to a useful purpose or it may be wasted—the one point at issue is the question whether the investment will pay a satisfactory return. The problem, in the main, is not unlike that pertaining to other lines of business. There is a certain first cost, and there are operating expenses and the like which are to be balanced against the income.

The fundamental characteristics which pertain to other enterprises apply to power transmission also. A power transmission plant, simply because it employs electricity, has no magic or potent influence whereby it may overcome the disappointments which are liable to follow rash financial speculation, stock jobbing or various kinds of mismanagement or short-sighted policy which would bring disaster to other enterprises. The increasing amount of capital which is being devoted to the development of new powers, as well as the extension of those which are well established, are substantial indications of the healthy financial basis upon which, in general, these enterprises are founded.

Power transmission may be considered from the scientific or electrical point of view. Those who are interested in this phase of the subject delight in those technical dissertations which deal with resonance and capacity and the phenomena which appear or which take on a new order of importance as voltages are increased. From this standpoint also one might consider the technical details in the design of high-tension apparatus in an investigation requiring a knowledge of electrical theory, an intimate acquaintance with the properties of insulating materials, supplemented by observation and experience.

There is another view of power transmission which may be considered, namely, the engineering aspect. The point of view is not that of the theoretical electrician or scientist, but rather that of the man who stands apart and views the subject from without. To this aspect of the subject it is proposed to give particular attention What, in the engineering sense, has been the trend in the development in general have been the problems of long-distance transmission? What which have been encountered, and how have the difficulties been overcome? What is the present state of the art, and what is likely to be the course of its immediate extension or development? The subjects which are brought to the front in these questions are those which are to be discussed in the following paragraphs.

In looking back, I recall an early book on the electric transmission of power, printed fifteen or sixteen years ago. Although there are many branches of learning and even of science and of engineering, in which a book which is fifteen years old may be a creditable work of reference—indeed, the last edition of the Encyclopædia Britannica, which still has a wide circulation, is even older—nevertheless this book on power transmission cannot be received as an acceptable standard for the present state of the art.

It opens with a description, simple and elementary, of the principles and construction of the electric machine—the dynamo and the motor—and there is a discussion of the relation between current and voltage and power and of the loss in conductors. There is a lengthy dissertation upon the characteristics and relative value of various methods of power transmissions, hydraulic, pneumatic, by wire ropes and other mechanical means, and by electricity. The part pertaining to long-distance transmission is devoted to a discussion of the series-wound, direct-current motor for use in a system employing a constant current and in which the high voltage is obtained by connecting several generators and also several motors in series. The book, excellent in itself, is not suitable as a work for practical guidance in transmission to-day for two reasons—first, the system it describes receives at present no serious consideration, no such system has ever been installed in America, and there have been but few elsewhere; second, the system in use to-day is not considered in the book—it is a later development.

Nor is the present system either a simple evolution from the one described, or even a modification of it—

the present system differs in toto. One is direct-current, the other is alternating; one is constant current with machines in series, the other is constant potential with machines in parallel. Speaking generally, the entire development of a long-distance power transmission as employed to-day in the transmission of millions of horse-power has been from beginnings which did not receive consideration in an engineering treatise on the subject published fifteen years ago. It has, indeed, been but ten years since the savants, who were to advise the electrical system to be adopted at Niagara Falls, finally and officially decided that alternating and not direct - current should be used.

What are the fundamental elements which have given the alternating-current system precedence and what have been the stages in its so rapid development to its present state of commercial usefulness? The one fundamental thing which underlies the adoption of the alternating current and the development of modern electrical transmission is the transformer. Its principle, its functions and its purpose are so well known that they require no elementary exposition. It may be of interest, however, to point out a very simple mechanical analogue in the transmission of mechanical power by a belt. If a power is to be transmitted from an engine shaft 8 to 10 inches in diameter to a second shaft parallel with it, a belt which could be placed directly on the two shafts would serve to transmit energy if they were of proper relative diameters, and would also effect any change in speed which might be desired. If the power to be transmitted were small, a horse-power or so, nothing further would be needed; but if it were several hundred horse-power, the size of belt for transmitting would be so large as to make it impracticable.

In order that a large power may be transmitted by a small belt it is necessary to increase the diameter of the pulleys and the speed of the belt. If the pulleys were of sufficiently large diameter, the pull upon the belt would be so small that a mere thread could transmit a hundred horse-power. Such an arrangement is mechanically impracticable, although the electrical analogue does not suffer the same limitations. When mechanical power is transmitted, the higher the belt speed, the less the size of the belt required for transmitting a given horse-power; likewise in an electric circuit, the higher the voltage of the transmission, the less need be the size of conductor necessary. By means of pulleys of suitable diameter the desired relation between speed and belt tension is secured in one case, and by means of transformers with suitable windings the desired relation between current and pressure is obtained for the electric transmission. Through the intervention of the transformer transmission pressures are usually not controlled or limited either by the voltage of the generator or the voltage of the distribution current. A generator may supply current directly to the circuits for lighting or it may be removed many miles, and the current actually transmitted may be only one-hundredth part of that either in the generator or in the lamps.

This well-known characteristic of the transformer has been fundamental in the great development, not only of the alternating-current system, but of long-distance electrical transmission as well, as the transmissions of to-day have been made possible and practical by the alternating current.

The transformer is beautifully simple in its elementary principles and in its construction—without moving parts, of high efficiency and automatic regulation, admirably adapted for its place in a transmission system. There is, however, a vast difference between the simple elementary form of transformer, in which two separate coils are linked together with an iron core, and the modern power transformer designed to transform hundreds or thousands of kilowatts at high voltages. Problems in the arrangement of the windings into a considerable number of coils, the problem of removing the heat generated throughout a large mass of material without undue elevation of temperature, problems of mechanically supporting heavy windings which are subjected to mechanical forces tending to produce vibration or distortion of the coils, as well as the problem of insulating the transformer to withstand the very high voltages which are normal to the service and those which may accidentally appear, due to lightning or other causes—all these things have brought into transformer design and construction many elements of both theoretical and practical difficulty.

The evolution of the transformer in the few years which have passed from the time when 40 or 50 K. W. at 5000 or 10,000 volts were the limit to the present time when transformers are built for 2000 or 3000 kilowatts and 50,000 or 60,000 volts, has required the highest skill in design and in construction to overcome the new difficulties which have continually arisen as sizes and voltages have increased. The transformer, however, has held its own, and its output has been made as large as other units in transmission systems have required, and it has supplied voltages as high as have been demanded by the transmission circuits.

The critical and limiting element in a long-distance transmission system is the transmission circuit. High voltages introduce exacting requirements upon the insulators. The insulator is subjected to mechanical strains, and must, therefore, possess adequate mechanical strength. Its material must be such as will resist puncture from the constant electrical stresses which are brought upon it, and its form and dimensions must be such as to prevent the passage of a trivial current over its surface which would quickly result in the formation of an arc.

The art of insulator making has undergone a wonderful evolution in the past six or eight years. The first insulators which were placed upon one of the most noted transmission circuits were of large size, designed and made especially for the high voltage which was to be carried. They were found to be inadequate, and as soon as others were available they were removed from the power line and tested. It was then found that the porcelain was not homogeneous, that there were openings and cracks and spongy places. When soaked in water not more than two or three insulators from the whole line of many miles in length would withstand the normal line voltage, which was only 11,000 volts. Great difficulty was experienced several years ago in getting glass insulators, which were very much smaller and lighter than those which are now regular commercial products.

The essential requisites in an ideally simple transmission circuit are the raising and lowering transformers and the line, and in the latter the insulator is the critical element. There are auxiliaries, however, which are scarcely less important to the successful operation of a transmission circuit. Notably among these is the protection from lightning or static disturbances from which sudden and very high pressures may occur which may easily break down insulation ample for the ordinary operating operating pressure of the system. The behavior of these instantaneous pressures is seemingly very erratic and completely disregards the ordinary laws of alternating current. Indeed, these pressures are as mysterious as are the phenomena of ordinary alternating current to one who has been familiar only with direct-current.

The phenomena resulting from lightning are comparable to those resulting from sudden impact in mechanics. A mechanical device which may be fully adequate for its ordinary service may be broken and shattered

by a blow. Mathematical research can, in a way, aid in an understanding of the general problem, and while experimental and laboratory investigation may do much to determine the relative strength and resistance of the different parts of a transformer or other apparatus to resist the stresses which come from high voltages, these alone are insufficient. In addition, there must be tests and careful observation under the conditions in actual service. It is the function of the protective apparatus to relieve the transformer from the abnormal strains to which it would otherwise be subjected.

It is usual to provide a short path, such as a spark gap, by which the charge at high voltage may pass without disturbance to the apparatus. The passage of a momentary current across such a gap breaks down the air insulation and thereby produces a short circuit, so that the ordinary voltage of the line, which was insufficient to break down the air gap in its initial condition will cause the flow of a very excessive current. Means of one kind or another must be devised to prevent or instantly interrupt such a flow of current, otherwise there will be an interruption to the service. On the other hand, the introduction of means for interrupting the current must not be of such a character as to impede the freedom of discharge, which is the fundamental object of the lightning arrester.

The development of a lightning arrester for the ordinary low voltages is a problem which has called forth the best energies of many able electricians. Even 500-volt railway apparatus is, unfortunately, not wholly immune to lightning. Each increase in voltage brings its new problems. The arrester for 5000 or 10,000 volts presents a quite different problem from that encountered at 1000 or 2000 volts, while the arrester for 40,000 or 50,000 volts again brings in difficulties of a new order.

The design of switches for operation at high voltages, the arrangement of high-voltage bus bars, circuits and wiring in stations, and the bringing of wires through the station walls are matters of very great importance, an importance, moreover, which is often not appreciated, and types of construction have been employed which, while quite satisfactory for low voltages, are wholly inadequate for higher voltages.

The several elements in the transmission system which have been discussed at greater or less length, including the transformer, the insulator, the protective apparatus and general station arrangements, have to do with the constructive, rather than the operative, features of a plant. A transmission system is a link between the power house and the sub-station. In the power house the whole object is the proper generation of current for the transmission line. The design and arrangement of prime mover, either water-wheel or engine, together with its speed-governing features, also the generators, switchboard, indicating instruments and the like, all form one unit which must operate uniformly and steadily to supply current to the circuit.

At the sub-station there may be switchboards, motor-generators, rotary converters and distributing circuits for motors and lights. These require, in general, a steady and constant supply of current at a constant voltage. The rotary converters and such synchronous motors as may be used must act in exact synchronism with the generators. Irregularity or fluctuation in speed of generators is instantly communicated to the synchronous machines in the sub-stations. If the variations are small, they may be inappreciable; if they are large, they may cause serious disturbances.

Again, the voltage at the sub-station, which should be steady and constant, is subject to various disturbing elements. Each increment of load tends to lower the speed of the prime mover, to lower the voltage of the generator and to cause an increased loss of voltage in the transmission circuit. A considerable drop in voltage, although momentary in character, may be sufficient to cause a synchronous machine to drop out of step. This, in turn, will cause it to take an excessive current and to come to rest. A change in the field current of a synchronous machine affects not only that machine, but to a greater or less degree modifies the voltage of the whole system. The system becomes much more complex and the possible interactions are greatly increased when several sub-stations, and, as in some cases, several generating stations also, are all connected to one transmission system, with its radiating, branching and usually duplicate circuits, each of three conductors for three-phase current.

This hasty review of the elements in a transmission system and of the nature of its operation indicates something of the advance which has been made in the development from the simple, ideal system, including simply raising and lowering transformers, connected by a transmission line, to the modern comprehensive transmission system. In illustration of the success with which such a system can operate, the writer may state an instance of one of the early suburban railways which was operated by rotary converters. The system comprised an alternating-current generating plant with high-voltage lines connecting four or five sub-stations containing rotary converters for supplying direct current to the trolley line. In addition to these sub-stations rotary converters were placed in the power house for receiving current directly from the low-voltage alternators and supplying direct current to the trolley line. In designing this plant a serious question was raised as to whether the voltage for the trolley line could be held within the limits of good service when the rotary converters were placed at different distances from the generator and supplied from a common transmission circuit. It was also recognized that there were many more links between engine and railway car motor in such a system than are found when a direct-current generator supplies current directly to the trolley circuits.

Recently the writer had a conversation with the manager of this plant, who, through recent consolidations, has a number of direct-current power stations under his supervision. He stated that the reliability of service through the alternating-current rotary converter system was greater than that in which the current is supplied from direct-current generators.

The success which has attended the alternating-current system is attested by the very large number of plants which have been supplied and the large quantities of power which are transmitted, as well as the industrial and commercial activity which are dependent upon this power supply.

The rapidity in the development of power transmission and the recognition of the serious and far-reaching problems which it involves have led the American Institute of Electrical Engineers to appoint a special committee for the collection of data and the discussion of topics relating to power transmission in general. This committee has undertaken two lines of work:—first, the collection of data, relating to construction and to operation, from managers and engineers of power plants; and second, the discussion of important subjects in transmission work. Its methods are to make a substantial aggregate out of small contributions from many active men. A leading transmission engineer has remarked that those who are not free to contribute from experience in order that by mutual interchange all may be assisted, may be suspected of being narrow-minded or having had unfortunate experiences which they fear to make known. The various members of the Transmission Committee of the Institute prepared short introductions to discussions on a number of important questions relating to transmission.

These were issued some time before the annual convention of the Institute last year. A day was given to power transmission. The various topics were presented, there was written discussion from members who were not present, and there was a general discussion by those present. Either by written communication or in person nearly all of the important transmission systems of the United States and Canada were represented. The remarks were brief and to the point, so that the record is a most valuable one. Considering the work which has been done by the power transmission committee, several features impress themselves. The first of these is the broad scope of power transmission. It involves many kinds of engineering and of engineers. A pole line, for example, has mechanical elements, such as strength of poles, insulators and wires, the relations between sag and temperature, the proper crossing of lines, the necessary distance between wires, as well as various electrical elements, including resistance, induction, capacity and the like. This is but a simple illustration of the requirements upon the engineer who undertakes the construction of a transmission plant. On the other hand, the various conditions of operation, such as have been pointed out in the foregoing parts of this paper, all show the various ramifications of the system and the variety of elements, mechanical and engineering, as well as commercial and industrial, which are brought together in one system through the transmission line.

A second generalization from the work of the transmission committee is the importance of emergency conditions. It is the unusual, the abnormal, the accidental which must be taken into account. Take, for example, the grouping of transformers. For three-phase transformers they may be either in the so-called delta connection or star connection. Considered from the academic standpoint, one would think particularly of the relative efficiency and regulation of transformers in the two arrangements. Considered from the standpoint of the designer, the relative sizes of wire in the transformers and the internal voltages would be the important matters. Considered from the standpoint of ordinary operation, a very important element lies in the fact that if one of the three transformers in the group be disabled and out of service, the other two may carry a partial load if the transformers be delta-connected, whereas the whole three are inoperative if they be star-connected.

In connection with one of the papers presented at last year's annual meeting of the American Institute of Electrical Engineers, it was pointed out that there are certain possible combinations of transformers and lines which may occur through accident or improper switching of circuits in which the transformers and lines may be connected in a certain way, so that the resulting voltage may be very considerably above the normal and may become a probable source of serious burn-out, and, further, that these conditions are not only possible, but are liable to occur with transformers connected in a certain way.

In general, each element in a transmission system must be arranged to meet not only the ordinary operating conditions, but those accidental or emergency conditions which may be caused through an improper connection or accident to some other parts of the system.

A third conclusion from the discussion on power transmission is that each element in the system is the result of an evolution. Each element, be it transformer, lightning arrester, insulator, switch, fuse, circuit-breaker or even the design of the station itself, has been subject to a regularly progressive evolution during the past ten years. Each increase in voltage has increased the difficulties of the class which had been encountered before, and has brought forward a new class of phenomena. The inventer, the designer, the manufacturer, the operator, all have steadily progressed to meet the advancing requirements. Take, for example, a collection of insulators representing the various types since the earliest transmission plants were installed, and one can see at a glance the evolution which has taken place in materials, in ideas and in manufacture. And this process is still going on. One of the most notable instances is in the switchboard arrangements in the large power houses recently built for alternating-current generation in the largest cities. When one remembers that it is only a dozen years or so since the introduction of marble mounted on iron framework superseded the early wooden structures, he can form some conception of the evolution which has led to a construction involving numerous galleries for bus bars in fireproof compartments, and for high-voltage switches for generators and outgoing feeders which are operated from a central operating stand near which are placed the various indicating instruments. Every new large station exhibits improvements in apparatus or in arrangement based on the experience in the preceding stations.

To the outsider, therefore, who views the development of long-distance power transmission from the engineering standpoint there is presented a marvelous achievement which has marked one of the most notable advances in engineering.

Simple in its elements, its problems become profound and intricate as distances become longer, as voltages become higher, as the quantity of power to be handled is greater and as the system becomes generally more extensive. Long-distance power transmission is notable for the development it has undergone—a development produced by the combined activity of many men.

There are still at work the same forces which have been at work in the past, forces which achieve results not by magic, not by wild invention or erratic ideas, but through definite, painstaking effort, in which thory and practice combine and interact to produce a regular, orderly evolution.

Experiences with Electric Automobile Charging Stations

By J. W. COWLES

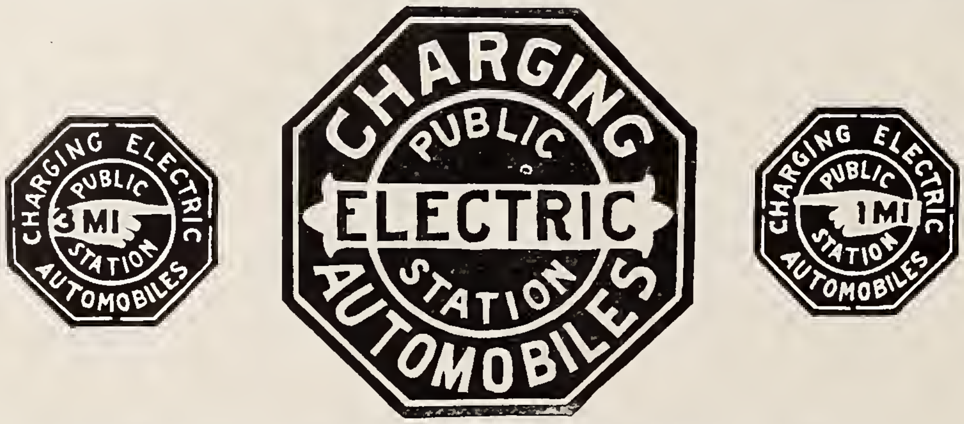
From a Paper Read at the Recent New Newcastle (N. H.) Meeting of the Association of Edison Illuminating Companies

EARLY in the spring of 1903 the Edison Electric Illuminating Company, of Boston, realizing the serious handicap placed upon the use of electric automobiles by the difficulty of obtaining proper charging facilities, and anxious to promote and develop this field for electrical supply, decided to establish throughout the eastern portion of Massachusetts a system of charging stations, so located that the automobile operator might feel reasonably sure of being able to make a considerable tour without the embarrassment of finding himself with batteries exhausted and unable to obtain necessary recharging current.

In practically all parts of metropolitan Boston, the alternating-current lines of the company were available for supplying such stations, and in the more remote districts efforts were made to interest other electric light and power companies to properly equip themselves with facilities for

battery charging. As a result of these efforts a very creditable system of stations was established.

Of the regular lighting and power stations in which arrangements were made, little need be said in the way of description; but the equipment of those stations for automobile charging alone may be considered with some care. In selecting locations for such stations, it was decided that livery stables were especially suitable for two reasons, namely, because they are, as a rule, open throughout the twenty-four hours, holidays included; and, secondly, that thereby the livery proprietor might be induced to look more favorably upon the growth of the automobile than he might otherwise be inclined to do.



ROAD SIGNS CALLING ATTENTION TO STATIONS WHERE ELECTRIC CURRENT MAY BE OBTAINED

Without a great deal of difficulty such locations were obtained in the various towns, the company agreeing to furnish and install all the apparatus entirely free of expense to the proprietor, he furnishing necessary space, care and attendance, and as compensation to receive a commission of 20 per cent. on all current sold—sufficient papers being signed to protect the company in the matter of ownership in case of assignment or fire.

The equipment consisted of a $6\frac{1}{2}$-K. W., single-phase motor-generator, with a starting rheostat on the motor end, as the installations were necessarily made upon lighting circuits. The switchboard for the entire control of both motor and generator cirrents was provided with a double set of charging posts, each with a regulating rheostat and recording wattmeter, so that two vehicles might be charged at once if needed. With the provision of charging cables with the different styles of connecting plugs, the station may be considered ready and waiting for business..

An important feature was the placing of suitable signs on the poles along the principal lines of travel, directing toward the nearest station at which charging current might be obtained. Two standard signs were adopted, as shown in the annexed cut, the larger one being placed at the station itself and the smaller ones on the poles along the highways. The customer applying at any of the stations is supplied with current sufficient for his needs, or to the extent of his time available for the purpose, and is charged on the wattmeter reading at 10 cents per kilowatt-hour, though no charge is made less than 30 cents.

Special efforts were made to interest and inform the public by the use of booklets and other printed matter on the subject generally, and especially as to the stations established. Believing that precepts should be practiced as well as preached, the Edison Company immediately put into use two service wagons, two delivery wagons, and two heavy trucks, the first four being of 3 tons and the last two of 5 tons capacity. All of these have occasion to travel the metropolitan district extensively. Other machines were afterwards added, and the operation of all has been made very successful by the aid of the system of supply stations.

In the care and operation of the charging equipments, some difficulties have, of course, been encountered, owing largely to the low grade of intelligence generally employed about livery stables, and to the lack of information as to the requirements of their batteries on the part of those operating vehicles. Naturally, it has been found somewhat annoying to be obliged to send a man several miles into the country in response to a telephonic message that no current could be generated, to find that neither the owner of the carriage nor the man on duty at the stable had given any thought to the necessity of closing the battery switch under the seat.

Such cases have raised the question as to the advisability of locating charging sets in places where greater knowledge and experience cannot be relied upon. With the present general tendency of former bicycle repair shops to equip themselves for automobile repair work, it would seem that such shops, now so generally to be found, would offer more satisfactory conditions for the successful operation of such stations, though it is not to be understood that the stable installations have failed to accomplish good results in general. The urgent need of a standard charging plug, universally adopted, has also been plainly demonstrated.

As to the revenues from such stations, it must be admitted that the returns are small, considered from an investment standpoint, but in the light of aggressive promoting and advertising, good work has been accomplished and steadily increasing returns are hoped for in the future.

While the electric automobile must of course be recognized as having a limited field, and in no way in competition with the various types of high-speed and long-distance touring cars, it may reasonably be expected that, within its field, such encouragement as described in the foregoing must do much toward enlarging its use, thereby adding one to the ever-increasing demands upon the central station for electric power.

Desirable Features in Insulating Materials

WITH those insulating materials which may be classed as paints or varnishes, says "The Electrical Engineer," of London, the following features are desirable, if not absolutely essential:—They should be quick drying, and yet not lead to great waste owing to the drying up of the solvent; they should have considerable elasticity and strength; should have a high melting point, and not lose their insulating properties or char with possible rises of temperature in practical use; should not chemically affect the copper conductors; must be waterproof and unaffected by oils, acids, and, as sometimes specified, salt water; last, but not least, should be good insulators.

With regard to insulating fibres, papers and tapes, some depend on the nature of the material for their insulating properties, while in others this is merely a medium for carrying an insulating varnish or paint, and it is on this that the strength of the insulator as such depends. This latter class, which also includes a certain variety of tapes, should, as far as the insulating medium is concerned with which they are impregnated, fulfill the conditions enumerated above for paints and varnishes.

Regarding fibres and papers in their "natural" state—that is, not impregnated with an insulating medium—they might be approved of if they meet

the following conditions:—They should be tough, yet pliable; should not suffer excessively as insulators should they be creased; they should, as far as it is possible to make them, be non-hygroscopic; should be able to stand all temperatures experienced in practice without charring or reducing their insulating properties; should have high insulation per mil of thickness, except where their mechanical strength is the principal consideration.

Electric Power in the Anthracite Coal Field

WHILE electricity has been heralded as the coming power for coal mines as well as other fields of industry, it is well to bear in mind that during the past twenty years engineers have responded well to the call for refinements in the application of steam and compressed air, and the close rivalry maintained in many mining operations is evidenced by the use of all three powers about some bituminous plants. Steam may be used for main hoisting, compressed air for driving under-cutting machines, and electric power or ropes for haulage. But it would seem that central stations, furnishing power for driving all the machinery about the works, both above and below ground, would have advantages that must receive recognition, particularly by large companies.

The foremost, if not the only case of this kind, in the anthracite field, as regards electricity, is found in the Hampton plant of the Delaware, Lackawanna & Western coal mining department, near Scranton, Pa. Several years ago a large boiler plant of 5000 H. P. was installed at this place, and quite recently a 2000-H. P. plant for the generation of electricity. What are called the "big companies," those combinations of collieries owned or controlled by the anthracite-carrying roads, are especially well adapted by circumstances to carry out the central station idea. Their collieries, or a number of them at least, are situated within a comparatively small area, furnishing ideal conditions for the establishment of one plant to supply power for all the machinery, such as hoists, pumps, fans, haulage plant and the machinery necessary for the preparation of the coal. It has been stated that to-day coal mining is largely an electrical and a mechanical proposition. Of course, even the most ardent advocate of the power transmitted by the copper cable will not advise its indiscriminate application; and in connection with this the report of the British commission appointed to investigate the use of electricity in the coal mines of Great Britain, furnishes a very conservative estimate of the value in which it is held in that country.

Naturally, we may expect to find the fullest development in that region of the anthracite field in which conditions most favor the adoption of electricity, and that is the Lackawanna-Wyoming region in Pennsylvania. In that territory the Lackawanna company has taken the lead. The generating station of this company, previously referred to, is equipped with Curtis turbo-alternators,—the first installation of the vertical steam turbine in the anthracite region. Current generated at this plant is carried to several sub-stations where it is transformed to lower voltage and converted to direct current for use principally in the mines of the Lackawanna company in the Keyser Valley for haulage, hoisting and pumping. Another installation of machinery which will derive its power from this station is the new water-hoisting plant which will hoist water through a shaft by means of tanks. This hoist will supplant a very large number of pumps scattered through the workings of the Keyser Valley, and is expected to be entirely automatic in its operation.

Another innovation in that section is the electric gathering locomotive. The assembling of the loaded mine cars into trips was formerly almost entirely done by the time-honored mule. When these loaded trips are made up at the several sidings, the usual form of electric mine locomotive hauls the cars to the shafts, through which they are hoisted to the surface. A number of these gathering locomotives are in use in the mines of the Keyser Valley and seem to be giving most excellent service. They are equipped with the ordinary trolley arm, and in addition carry a reel, on which is wound and unwound a cable, supplying the motor with current from the feeder on the main haulage way. This arrangement permits the locomotive to use current several hundred feet distant from the line on which the trolley arm runs when the cable is accessible.

The operation of the machinery in the breakers is also receiving the attention of the electrical engineers of these same companies. Here again we find the Lackawanna company in the van, for several years ago they equipped an experimental breaker at the lower end of the Wyoming Valley with individual motor drives. For the enlightenment of those unfamiliar with the preparation of anthracite, it may be said that the location of line shafts, belts and gears, when the breaker machinery is driven by a steam engine, is a most complicated problem. The simplicity of the arrangement employing individual motor drives is obvious. A large breaker thus operated is also understood to have been quite recently equipped by the Delaware & Hudson Company—another of the big anthracite companies.

That electricity is adapted to percussive drilling, is illustrated in the adoption of rock drills driven by electricity in tunnel work. A large number of cross-cut tunnels from one seam to another and leading to shafts and slopes are being driven by such drills; and while figures are not at present available to show the economy of electrically operated drills compared with the cost of operation of those driven by other means, still the large number in use is significant.

Pumping and hoisting by electricity have been in vogue for a number of years and there are few manufacturers of any prominence, furnishing these types of machinery, who are not prepared to send out pumps and hoists equipped with electric motors. Their advantages are well known and their use within certain limits is very general. But with the present demand for large units on important and heavy work, further development will be necessary before the general adoption of electric types will be recommended by those having charge of the mechanical equipment of collieries. This holds true particularly in the case of large hoists on main shafts. Small electric hoists have been very extensively and satisfactorily employed on underground slopes and shafts for years, but only recently have large installations attracted any considerable attention, simply for the reason that until the last year or so none were in operation.

The largest hoists, electrically operated, for main shaft hoisting in this country, are stated to be those working on the Comstock Lode in Nevada, but even these are equipped with motors of only about 300 H. P. Within the last year or two several of the largest coal mining companies of Germany have installed electric hoists of several thousand horse-power capacity on their main shafts, and the outcome of their operation ought to be of considerable interest. To-day Germany is practically the only country that has made any showing worthy of note in this field.

THE ELECTRICAL AGE

Volume XXXIII Number 5
$2.50 a year; 25 cents a copy

New York, November, 1904

Entered at the P. O. as 2d-class matter. Copyright, Louis Cassier

ESTABLISHED 1883

Published monthly at 3, 5 and 7 W. 29th Street, New York City.
Telephone No. 1617 and 1618 Madison Square. Private branch exchange connecting all departments. Cable Address—Cassier, New York.

SUBSCRIPTION RATES

The Electrical Age will be sent post free anywhere in the United States and its possessions, Canada and Mexico for $2.50 per year, single copies 25 cents. To Great Britain and all countries embraced in the postal union, $3.75, 15 shillings, 19 francs, 15 marks, or 10 rupees. Send subscriptions to our nearest branch office or agency.

NOTICE TO ADVERTISERS

Insertion of new advertisements or changes of copy cannot be guaranteed for the following issue if received later than the 15th of each month.

LONDON OFFICES

Business Department, 33, Bedford Street. Editorial Department, 22, Henrietta Street. Covent Garden, Strand, W. C.

London Telephone, Post Office, 3807 Central. Private branch exchange. London Cable Address—Revolvable, London.
All remittances to London Office should be crossed London and County Banking Company.

BRANCH OFFICES AND AGENCIES

Subscriptions may be sent to the following branch office or agencies, where they will receive the same careful attention as at the home office in New York:

124, Queen St., Melbourne
359, George St., Sydney
61, Main St., Yokohoma
23, Esplanade Rd., Bombay
33, Loop St., Cape Town
Unter den Linden, 5, Berlin
Nevsky Prospect, St. Petersburg
31, bis rue de Fauburg Montmartre, Paris

General Agents for United States and Canada: The American News Company

Leading Articles

Electrical Display at the Knights Templar Conclave. By H. W. Jumper 321
Direct-Current Switchboards. By Bertrand P. Rowe 325
Cable Laying and Telegraph Line Construction in Alaska. By George E. Walsh 333
The Steam Turbine in Central Station Practice. By W. L. R. Emmet 336
Electric High-Tension Line Construction and Operation. By Dr. F. A. C. Perrine 342
Thawing Out Frozen Water Pipes Electrically. By William Mayer, Jr. 353
The Handling of Freight by Electric Roads. By Lemuel W. Serrell 357
Electricity Day at the St. Louis Exposition. By Cloyd Marshall 359
The Commercial Development of Water Power. By Alton D. Adams 361
Long-Distance Power Transmission. By Charles F. Scott 364
Experiences with Electric Automobile Charging Stations. By J. W. Cowles 367
Fire Streams as Electric Conductors 370
Electric Omnibuses vs. Street Cars 370
Stealing Copper Wire from Electric Circuits 371
Overland Wireless Telegraphy 371
Electric Central Station vs. Isolated Plant 371
Wireless Telegraph Earnings 372
Electric Omnibuses vs. Street Cars. By Alton D. Adams 373
Trackless Trolley Lines in Germany. By Joseph J. Langer 390
Cooking with Electricity. By D. A. Willey 392
The Nernst Lamp. By E. R. Roberts 394
Electric Safeguards for Ocean Travel. By George L. Clark 398

Fire Streams as Electric Conductors

THE question as to the extent of the danger to which firemen may be subjected in the event of a stream of water from their hose coming in contact with high-tension transmission circuits is one that continually crops up. Experiments to determine this point have been carried on in Europe for several years past and always with the effect of demonstrating that a dangerous current is not carried by the water to the nozzle.

More recently, in this country, a series of experiments were made under the auspices of a committee of the New York Street Railway Association for the same purpose and with the same result. Streams of water were thrown directly on a 600-volt electric traction circuit at a distance of 20 feet from a line of $3\frac{1}{2}$-inch hose, with a $1\frac{1}{8}$-inch brass nozzle, and not the slightest sensation of shock was experienced, even when the experimenter was standing on the iron rail of the track with his hand on the brass nozzle. This was also the case when the stream was directed against the transmission wires of a 20,000-volt circuit. Still better evidence of the non-conducting qualities of hydrant water was given when the stream was thrown across the wires of the high-tension transmission line which were not more than 2 feet apart. This was done without making a short circuit.

When it is considered that pure water is a non-conductor of electricity, these results might have been expected. In fact, similar experiments were made over thirty years ago to ascertain whether dense fogs affected the insulation of telegraph wires by conducting the current directly from the wire to earth, and tests made with the most sensitive instruments then available failed to disclose the slightest leakage of that nature. Pure sulphuric acid is also a non-conductor of electricity, but it is well known that a mixture of water and this acid is conducting. The presence of moisture or water on wooden poles and cross-arms, where admixture with dust and acids or alkalies is probable, brings about conditions in which current will escape from the wires to the earth or from wire to wire. That such escapes went on from the poles was, of course, evident in telegraph practice from the manner in which the insulation resistance of the lines fell in rainy or foggy weather, but the potential of the lines was not sufficiently high to make this escape manifest by simple contact with the poles. With potentials of 2000 volts and more, however, it is quite possible to obtain somewhat severe shocks by contact with the wooden poles of such lines in wet weather.

Letter carriers in some cities have especial reason to be aware of this fact when they attempt to open the letter boxes supported on the wooden poles of high-potential lines, in wet weather, unless they first take the precaution to insulate the key of the box with dry paper or rubber tape. This difficulty, as well as the entire possibility of receiving such shocks, can readily be obviated by placing an iron band connected with a ground wire around the pole about 6 feet from the earth. Obviously, shocks cannot be obtained from iron poles unless they are so thoroughly embedded in dry cement as to be insulated, a condition which, in wet weather, or indeed at any other time, is not likely to exist.

Electric Omnibuses vs. Street Cars

SO much has been heard in the recent past of the possible competition of automobiles with street cars in the handling of passenger traffic, and so little has been done toward developing that competition, that the proposed operations of the Manhattan Transit Company in the city of New York, to begin with the new year, are worth noting, particularly as they promise, as it would at present seem, to lead to a practical result.

Generally speaking, they are to provide a system of automobiles, or autobuses, to use the company's more expressive term, which will carry passengers on time service along certain predetermined routes at current street car rates of fare. Electric storage batteries are to supply the power, and with the accompanying refinements of rubber-tired wheels and street pavements much superior to those of a generation ago, the apparent reversion to first principles in readopting the

omnibus idea will be deprived of all semblance to a retrogressive move.

What such a system may be expected to accomplish is very well presented elsewhere in this issue by Mr. A. D. Adams, in an article entitled "Electric Omnibuses versus Street Cars." Mr. Adams makes out an excellent case for the auto-bus,—one from which the Manhattan Transit Company ought to be able to derive a good deal of peace of mind.

Stealing Copper Wire from Electric Circuits

IT would, at first sight, seem that there would be very little inducement to thefts of copper wire from poles, considering the likelihood of detection, not to speak of the danger to life connected with the operation; but, as a matter of fact, no country is exempt from depredations of this nature. In the case of one high-tension electric lighting system the service has been interrupted at different hours of the night by the removal of hundreds of feet of wire from the poles by expert pilferers. Similar reports have at different times come from many places, and in one instance telephone service was seriously crippled by the unwarranted removal of large sections of copper wires from the lines, the iron wires of the same system being left untouched. Nor is this a new industry, for it has been going on for years.

One of the chief obstacles, it appears, in the way of preventing this form of larceny is the difficulty on the part of the companies in proving property unless when the pilferers are caught in the act, for there are no identifying marks on copper wire, especially after it has been melted. It is interesting to note, in connection with this, that one Moses Wright, as long ago as 1852, was found guilty of merely cutting the telegraph wires in Marlboro district, S. C., and for this offense was sentenced "to receive thirty-nine lashes on the bare back, publicly, to leave the district in ten days, and each and every time he was caught in the district to receive thirty-nine lashes, without farther trial."

Overland Wireless Telegraphy

IT has been mooted for some months past that a wireless telegraph circuit is to be established between the plants of the General Electric Company, at Schenectady, N. Y., and Lynn, Mass., a distance of 185 miles. Recent inquiry, however, has elicited the information that but little has been done as yet in the equipment of the necessary wireless outfits at these places. It is understood that the system selected for the experiment is that of the National Electric Signaling Company, of Washington, D. C., which exploits the Fessenden wireless telegraph devices.

Some speculation has been indulged in as to the saving that will accrue in telegraph and telephone tolls by the use of a wireless telegraph circuit between the points in question. It has been said that preparatory to cooking a rabbit the animal must first be caught. Analogously, before any estimate need be made of the economies to be brought about by a wireless telegraph system, in the displacement of the ordinary telegraph and telephone systems, the wireless system should first be "caught," and, so far as practical overland wireless operation to any great distance is concerned, it appears to be as elusive as the quadruped to which reference has been made.

A notable feature of almost all the experiments that have been made with wireless telegraphy is the evident desire of the experimentalists to traverse great distances before practically demonstrating that much shorter distances may be negotiated, using the word in its sporting sense. For more than a year, as stated in these columns last month, there has been in experimental operation a wireless telegraph system between Jersey City, N. J., and Camden, N. J.,—virtually between the suburbs of New York and Philadelphia. Here, if the system is ready for commercial overland work, is a circuit right at hand to give a practical demonstration of the fact, but for some reason, inexplicable to well-wishers and skeptics alike, the demonstration is postponed, while, if reports be true, experiments are to be commenced between other points where the distance to be signaled over is doubled and the difficulties of transmission are at least quadrupled.

Electric Central Station vs. Isolated Plant

IT appears to be difficult to determine whether it is more economical, even in large cities, to operate an isolated plant for electric light and power, or to use a central station supply, so conflicting are the views held upon this subject and so admittedly indefinite is the information obtainable from those most capable of imparting that information. There is no doubt that the central station can develop electrical energy at a much lower figure than even a fair-sized isolated plant, perhaps at one-third less for coal alone, besides which the central station, as a rule, has a high load factor and improved facilities for economically handling coal and ashes, and thus has lower labor charges per kilowatt-hour than the isolated plant.

There are, however, against these advantages the heavy losses in distribution between the switchboard at the central station and the consumer, which may be as high as 50 per cent. and rarely less than 20 per cent. It would at first seem that there should not be much doubt that the central station source of supply is cheaper than the isolated plant for small users of electrical energy, although even in this case the fact that the central station rate per kilowatt-hour is greater to the small user than to the large user is in favor of an isolated plant for the small user. Such statistics as are available show that savings have frequently followed the installation of comparatively small isolated plants.

One thing that conduces largely to this result is that steam is necessary in a building for heating purposes, and thus, so far as the electric plant is concerned, labor charges are almost eliminated. The cost to the consumer of electrical energy from the central station supply, in American plants, ranges from 4 to 15 cents per kilowatt-hour and that of the isolated plant from 2 to 12 cents per kilowatt-hour, with an average in the latter case of less than 6 cents per kilowatt-hour, depending on the conditions prevailing in each building. Where gas engines are employed to operate the dynamo the average cost per kilowatt-hour is somewhat higher. Notwithstanding these figures, however, the central station inspectors appear able to give convincing reasons why it is advisable to use their supply, as proved by the large number of isolated plants in some of the large cities that have been shut down, their places now being taken by the central station supply.

A rather good, or bad, story has recently been told illustrating the arrogance, ignorance, or whatever it may be called, of the executives of some of the trades unions in dealing with their members. It appears that while a workman was engaged in guiding a cable into a conduit in a building that was being wired, his fingers were caught between the cable and the walls of the conduit. The men at the far end of the conduit, unaware of their comrade's plight, continued to pull upon the cable, seeing which an apprentice lad ran to his assistance and pulled back on the cable. A delegate of the union who had witnessed the affair and had expressed

sympathy for the sufferer, reported him for violation of the rules of the order, and the latter was called to executive headquarters to explain his conduct. Notwithstanding that his fingers bore evidence to the extent of the accident he had undergone, he was fined "for allowing an apprentice to do helper's work, to wit, assisting a journeyman drawing wire into conduits."

Wireless Telegraph Earnings

THE daily newspapers are still printing columns of advertisements relative to wireless telegraph systems, in which statements relative to the prospective earnings and profits of such systems are very alluringly set forth; and some of the later statements imply that the success of certain wireless companies in Europe may be taken as a criterion of the success that will follow here. It is quite possible that the British Marconi Company is on a paying basis, owing to the large number of warships and mercantile vessels, lighthouses, etc., now equipped with that system. On this side of the Atlantic, however, the number of wireless equipments is much more limited, and what business there may be is divided among at least three different companies, with a corresponding division of earnings.

Indeed, it is probably within bounds to assume that few, if any, of the American companies are at present realizing sufficient income from the commercial operation of their systems to meet even the expenses of the legal controversies over alleged infringements of patents which are now proceeding between at least three of those companies. One of these controversies concerns the use of an imperfect contact, such as the filings coherer or its equivalent, in wireless telegraphy. Another is for infringement of the liquid barretter, or electrolytic detector, whichever the device may ultimately be held to be by the courts.

This latter is a pretty enough contest as it stands and, apparently, the result will hinge upon the question as to whether the action of this detector, which consists of an exceedingly fine, short wire in a dilute acid solution, is thermic or electrolytic. If thermic, the device will probably be held to be covered by the claim in one patent; if electrolytic, by the claim in another patent, the respective patents being controlled by different interests.

It has been suggested that electric capstans be placed at the upper end of one of Liverpool's heavy-grade streets, for hauling up wagons or other conveyances.

Brief Topics of the Month

The imports of Russian petroleum into England show a considerable increase during the first half of the year 1904, the Russian oil gradually crowding out the American product. The imports from Russia during that period amounted to 78,836,000 gallons, exceeding the American imports by about 13,000,000 gallons.

The New York Telephone Company has now 144,495 instruments connected in Manhattan and in the Bronx. This is an increase of more than 23,000 since September, 1903. Ten years ago the total number of instruments in use was 11,835.

A heat storage system has been installed in the London power station of the Kensington & Knightsbridge Company for increasing the boiler capacity during the period of the "peak" load. Each of the boilers is of the water tube type and is capable of evaporating 12,900 pounds of water per hour. The thermal storage vessels are placed directly above the steam and water drums, and are about 22 feet long, and 54 inches in diameter. During times of light load the vessel is full of water, which is warmed by means of coils of live steam. When the heavy load comes on, the feed from the pump is stopped, and the boilers are fed from the hot water in the storage tanks.

It is stated that an experimental single-phase railway line is to be constructed at the British Westinghouse Works, at Trafford Park, Manchester. It is expected to be in operation before the end of the year.

The Navy Department has in view the transmission of time signals by wireless telegraphy for the benefit of the Navy and of the merchant marine, with Key West as the first center, whence it is proposed to flash noon signals. "Ball Time" on the high sea by wireless is one of the innovations due to progress in this line of science, and it is believed that this idea will prove of great and increasing value to those who go down to the sea in ships. Key West will be connected with the Washington Naval Observatory.

In accordance with the suggestion of former president Charles L. Edgar, at the Boston meeting of the National Electric Light Association, an investigation of methods in use for the thawing of frozen water pipes by electricity, is now being made for the benefit of members. George S. Haley, of Rutland, Vermont, has been appointed by President Davis as a committee to report on this subject. He has the work already well under way, with a view of publishing results before freezing weather sets in. He contributed a very full and instructive article on this subject to the "Wrinkle" department of the Boston convention, having had considerable experience in the use of electricity for this purpose, and his report, including the experience of companies under differing conditions, will be looked for with interest by members located in the zone of severe frost.

The Union Pacific Railway has arranged to supply a telegraphic news service to passengers on the overland limited twice each day. Bulletins of the most interesting events in the United States and foreign countries are to be sent out from Omaha at noon and at 4:30 o'clock P. M., and these dispatches will be posted in the observation cars. Two eastbound trains and two westbound trains, each 24 hours apart, will be supplied with the service at the same time.

The first German electric railway was put into operation in 1879 in Berlin. It was only 300 meters in length. On October 1, 1903, German electric railways embraced 2200 miles of line and 3300 miles of track. They operated 8702 motor cars and 6190 trailers.

The High Commissioner for South Africa has rendered a decision to the effect that the following articles, falling under item 63 of the tariff of the Transvaal, providing for machinery and parts, are dutiable at the rate of 2½ per cent. ad valorem:—Accumulators, batteries, dynamos, electric cable, electric pumps, and electric motors.

The Mexican Railway known as "The Queen's Own," the oldest railroad in the republic, proposes, if consent be given by the London office, to adopt electricity along the entire line from the City of Mexico to Vera Cruz. The system recommended is the trolley system, and it is estimated the company would save approximately $500,000 annually on coal. The railway was commenced in 1857 and completed in 1873, and its operation has never resulted in the loss of life among passengers.

A complete telephone system has recently been installed in the penitentiary at Salt Lake City, Utah, connecting all departments and every guard in the prison.

At a dinner given to foreign electrical engineers by the General Electric Company, recently, the ice cream was fashioned to represent electrical apparatus.

Electric Omnibuses vs. Street Cars

A Promised Development of the Coming Year

By ALTON D. ADAMS

VEHICLES, driven by storage batteries and electric motors, are now a recognized means of transportation, but the importance and extent of the service they are to render in city streets remains to be determined. Opinions are freely expressed that electric motors will displace the horse with independent vehicles for urban purposes, but the possible competition of such vehicles with the present street cars has received little attention.

Passenger transportation in city streets has developed by a series of revolutionary changes. It was a long step from the bus, free to travel in any part of any street, to the car running on rails, confined to a single route in those streets where rails were laid. Even more radical was the change from animal power, applied at each car, to steam power developed in one or more central plants and distributed by a moving cable beneath the surface of the street. Greatest of all was the innovation when a stationary electric conductor displaced the moving cable, and a single generating plant was able to move hundreds of electric cars in scores of different directions at the same instant of time.

Looking back at these several changes in the methods of passenger transportation, the main incentive of each is seen to have been cheaper operation for a given service. The operating cost per passenger per mile carried is less for the horse car than for the bus, less for the cable car than for the horse car, and least of all for the electric car. This gain in purely operating expenses has been great, but it has not been attained without sacrifices in other directions.

Fixed charges on the investments, limitations in the flexibility of systems and objectionable structures in streets have multiplied as the expenses of operation have diminished. Perhaps the only exception to this last statement is found in the change from cable to electric traction, which brought increased flexibility of operation as well as larger investment. The capital invested in bus and horses per passenger transported was very small. These vehicles could travel in any part of any street, required no special structures underneath or overhead, and most of the charges against them were those simply of operation. Horse cars required a considerable increase over the investment necessary for transportation by bus, both because of their heavier structure and more on account of the cost of rails. With cable cars, the fixed charges per passenger advanced another and larger per cent., while the track became more highly specialized. It remained for the system of electric traction to reach the maximum of investment per unit capacity of equipment, and to introduce aerial as well as surface structures in the streets.

That electric street cars effect so great a saving in operation as to more than offset the higher first cost and other disadvantages of the system compared with any that preceded it, may be taken as proved by their extensive and extending application. It by no means follows, however, that electric street cars, operated over definite routes, in connection with elaborate overhead structures, and all directly dependent on a distant power station, represent the final development of transportation in city streets.

Electric street cars are apparently near the end of a long line of development, of which the main object has been reductions in operating expense for certain qualities of transportation service, though the standards of quality have much improved. If the perfect tends to disappear, and little more is to be expected in the reduction of operating expenses for electric cars, the time seems ripe for the advent of a new system of public transportation in city streets. Electric vehicles, it is argued, constitute the elements of such a system. These independent vehicles, driven by their contained batteries, seem ready to carry forward the development of city transportation toward smaller investments and fixed charges per unit capacity, greater flexibility of service and freedom from all special structures in the streets.

Against the view that vehicles, independent of any rails or structures for the power transmission, can displace electric street cars, it is urged that the cost of operation for such vehicles is too high to allow them to seriously compete in the great bulk of public transportation. To compare the advantages of street cars and independent vehicles driven by batteries, for passenger traffic in city streets, the savings of the former, if any, as to purely operating expenses should be weighed against the low investment, flexibility of operation and freedom from the street structures of the latter. It is, of course, understood that in some limited classes of transportation, such as that by cabs, it is simply a question between independent motor or horse vehicles.

Though data are not at hand to show the exact disadvantage, measured in money, of street car rails in the streets, it is a matter of general observation that this disadvantage, including the frequent digging up of pavements, is large. The overhead structures generally used with electric cars are by no means so objectionable as they have sometimes been made to appear, but few will contend that they add to the beauty of streets. There seems to be little doubt that the substitution of independent battery motor vehicles for electric cars would result in much quieter streets, through the use of wheels with rubber tires or tires of some other comparatively noiseless substance.

As the now used cars are confined to a fixed portion of the streets in which rails are laid, travel in them must be confined to these streets. A result is, where several streets go in the same general direction, that the cars are generally congested on parts of such streets, whereas independent motor vehicles might use all of these streets with equal facility. In cases of accident, by which a line of rails is temporarily closed, travel on certain lines is, at times, seriously impeded. One of the most notable features of the demand for urban transportation is its concentration at certain hours of the day, and in most instances it is impossible to move cars over existing lines of rails fast enough to meet the maximum demands. Such lack of capacity is due not only to the fact that rails are laid in only a part of

existing streets, but also to the inability of cars going in the same direction in one street to either pass one another or to travel two or more abreast, as independent vehicles can readily do.

Coming to the matter of investment for the system with independent vehicles, driven by storage batteries, as against the present system of electric cars—both require generating stations. The maximum capacity of the generating station necessary for independent electric vehicles is much less than the capacity necessary for the operation of street cars where the total daily output of energy is the same in each case. This difference in the necessary station capacities for these two traction systems is due to the very unequal demands made on a power station by cars at different times of day. However short the period during which the maximum demand on a power station is made, the capacity of the equipment must be sufficient to meet it. For about one hour at the close of the business day the demands on power stations by street cars are often three or four times the average load during each twenty-four hours.

Such demands are usually met, in large part, by an equipment of boilers, engines and dynamos larger than required by the average demand, and also frequently, to some extent, by an auxiliary plant of storage batteries, these last being located either at the main station or at sub-stations. But the differences in amount between the maximum and average loads at the power stations of electric railways are much greater than it has been found desirable to supply with storage batteries alone, and the equipment of boilers, engines and dynamos at such stations, therefore, often has a capacity two or three times as great as the average load. A change from cars to independent electric vehicles would make it at once practicable to develop the necessary electric energy for each day at such times as are most advantageous, instead of those times when it must be used. In other words, a generating station for independent vehicles could have its equipment of boilers, engines and dynamos proportioned for the average instead of the maximum demands of the transportation system.

It follows that, for a given daily output of energy, the station to charge storage batteries for electric vehicles need have only one-half or one-fourth the capacity in generating machinery that is necessary for the operation of a car system, and would require no battery plant whatever. With this smaller generating equipment the investment for land and buildings is likewise largely reduced in amount.

Electric cars have thus far remained very heavy and expensive in construction per unit of passenger capacity. These features of such cars are largely due to the requirements of use on fixed steel rails, where an accurate and very rigid construction is necessary, and in order to meet these requirements the familiar construction with cast-iron wheels and heavy steel frame has been adopted. Partly from custom and partly from the necessities of the case, the bodies of electric street cars are heavier than would be the bodies of independent vehicles of equal carrying capacity. In view of their weight and expensive construction, it is safe to assume that the cost of independent vehicles, to be driven by storage batteries, would be no greater than that of the cars, per passenger capacity, not including the cost of the batteries.

The cost of storage batteries and also their weight for a vehicle of given passenger capacity and power requirements depend, in large measure, on the time during which a single battery equipment, or a single charge of that equipment by the generating station, must supply energy to move the car. So long as the maximum rate of energy output of the storage batteries is not exceeded, the weight of the batteries necessary to supply any given power may be reduced directly as the time is reduced during which the power must be furnished. The importance of this property of battery equipments, in its bearing on their weight, may be seen from the fact that batteries of standard makes may be discharged without injury in as short a period as three hours. This capacity for rapid working makes it possible to reduce the weight and cost of vehicle batteries to a very moderate figure, provided they can be replaced or recharged at short intervals, corresponding to the minimum periods of discharge.

An extensive system of transportation with independent vehicles in city streets may readily take advantage of this rapid discharge capacity to any desired extent, because the conditions of operation would permit the batteries to be charged and recharged at short intervals. Charging stations could easily be so arranged that each vehicle engaged in town or city transportation could pass one of them at least once during each period of battery discharge, even at the maximum normal rate. With suitable arrangements at the charging stations the discharge batteries could be removed from a vehicle, and others, newly charged put into position during less than one minute.

Though the discharge of batteries at their maximum normal rate makes it possible to maintain a given rate of work with the least possible battery weight, such a practice involves some loss of efficiency, and this loss must be weighed against the advantages of light weight for each particular case. For purposes of illustration, a rate of discharge that brings the battery to the point of recharging at the end of a five-hour period may be assumed as one that combines high efficiency of operation and moderate weight. An independent electric vehicle seating twenty people may be fairly taken to weigh 4 tons, complete with batteries and passengers. Tests on a considerable number and variety of electric vehicles have shown that 100 watt-hours are a sufficient allowance of energy delivered to motors per ton-mile of transportation.

Allowing 10 miles per hour as the travel of each car, the transportation during five hours is $10 \times 4 \times 5 = 200$ ton-miles. Since 100 watt-hours or 0.1 kilowatt-hour are required per ton-mile, the vehicle with twenty people consumes $200 \times 0.1 = 20$ kilowatt-hours during its five-hour run. One hundred pounds are sufficient allowance for weight of battery per kilo-

COST OF SOME AMERICAN ELECTRIC STREET RAILWAYS

Costs	Springfield Street Railway Company.	Worcester Consolidated St. Ry. Co.	West End Street Ry. Company.
Railway	$1,168,061.87	$1,228,011.32	$9,022,765.30
Equipment	450,652.20	316,400 62	6,909,277.95
Land and buildings	703,932.05	205,454.21	10,778,311 63
Total investment	2,322,646.12	1,749,866.15	27,002,629.98
Percentage of total cost in railway	50.2	70.1	33.4

Costs	Lynn and Boston Railroad Company	Lowell and Suburban St. Ry. Company	Lowell L., & Haverhill St. Ry. Co.
Railway	$4,432,259.71	$1,279,249.24	$1,747,864.17
Equipment	1,446,087.22	339,830.07	678,676.47
Land and buildings	1,442,889.32	584,521.90	670,645.82
Total investment	7,321,236.25	2,364,391.16	3,099,349.06
Percentage of total cost in railway	60.5	58.3	56.3

Costs	Repairs on Track and Electric Lines	Cost of Electric Energy
Springfield Street Railway	$39,222.71	$48,777.48
Worcester Consolidated Street Railway Company	29 292.28	84,626.71
Boston Elevated Ry. Co. operating West End St. Ry. Co.	969,360.86	462,482.52
Lynn and Boston Railroad Company	86,151.55	96,256.10
Lowell and Suburban Street Railway Company	16 448.22	21,470.22
Lowell, Lawrence and Haverhill Street Railway Company	27,380.15	42,712.74

watt-hour of capacity, so that the battery weight for this case is 2000 pounds.

As the maximum number of cars or vehicles in a system is in use during only short periods daily, it is probably sufficient to allow one and one-half complete battery equipments for each vehicle, so that at least one-third of all batteries may be charging even at times when all vehicles are in use. The capacity of the total battery equipment per vehicle on this basis is 30 kilowatt-hours, and, at a price of, say, $30 per kilowatt-hour, its cost is $900. As the batteries on each vehicle are here proportioned for delivery of 20 kilowatt-hours during five hours, their rate of work is 4 K. W.

The cost of electric generating stations, including land, buildings and all equipment for the development of electrical energy, may easily reach $300 per K. W. of output capacity. Four K. W. capacity at a generating station, to deliver energy at the same rate as the batteries on each car, costs, therefore, $1200. If one-half of the generating capacity at the station can be dispensed with, where vehicles with batteries are used, because of the long and uniform load which they afford, one-half of the cost of the station may be saved, or two-thirds of the total battery cost. The higher efficiency of the system with battery vehicles, compared with that of electric cars supplied directly by the power station, will still further reduce the comparative costs of generating equipment for the two cases.

Coming to the cost of rails and electrical circuits for the street car system, it may be noted at the outset that these items are entirely absent in the system with independent vehicles. The cost of rails and of the overhead and underground electric circuits that connect cars with power stations is usually much greater than that of any other element in a street railway system. To show the relative investment in rails and electric circuits, compared with that necessary in other property for street railways, the table on the opposite page has been compiled from a recent annual report of the Massachusetts Board of Railroad Commissioners. In the items of railway cost the total investment, for each case, in rails and overhead and underground electric circuits is included. Under cost of equipment are included all investments in cars and other vehicles, and a few horses, and that in furniture, tools, and minor machinery. The cost of land and buildings includes power stations and their equipment, and all other land and buildings necessary for the operation of the railways.

In the case of the West End Street Railway Company the item under land and buildings is believed to cover a large amount of real estate no longer used for railway purposes, and this probably accounts for the unusual percentage of the total investment under this head. The total cost shows the entire permanent investment in the complete railway system for each case. The percentage of total cost in railway in the table represents the ratio of the investment in the railway and electric construction, divided by the total investment. If battery-driven vehicles were substituted for electric cars, the investments for railway and conductors, averaging more than one-half of the total, would be entirely avoided, and the investment in land and buildings, with generating machinery, largely reduced.

The table also shows the cost of repairs on tracks and electric lines, and the cost of electrical energy for motive power per year. The former varies from less than one-half of the latter, as at Worcester, to more than twice the latter as at Boston. Such variations are probably due, in large part, to the differences in extent and character of paving in the several cities, and also to the fact that electrical energy is more economically generated in the larger plants. If vehicles with batteries displaced the present street cars, the entire item for repairs on rails and line would be avoided, and this amount, as shown by the table, may be taken as approximately equal to the present cost of motive power.

There seems to be no good reason to expect an increase in the cost of electric motive power if battery vehicles are substituted for the cars in any given system. The total average weight per passenger should be about the same for battery as for the present cars, and any disadvantage of pavements compared with rails, as to rolling friction, would be nearly offset by larger wheels on the vehicles. In the generation of the electric energy a station charging vehicle batteries would have a great advantage in economy of operation over a station delivering energy directly to street railway lines, because, as already mentioned, engines and dynamos could be worked at nearly full and uniform loads in the former case. In street car systems, as now operated, a part of the dynamo output goes first to station batteries, but the greater portion flows at once to the car motors. The energy that goes first to batteries is subject to a double loss, as it must also pass through the line to the motors. Energy supplied to vehicle batteries would be subject to no loss in lines, but only to that in the battery, which may be taken at 30 per cent. of the total.

The loss of energy in the electric lines and in the rails that connect station dynamos and car motors is subject to great variations in different systems, but 20 per cent. is probably as low a figure as can fairly be assigned to this loss on an average. As line pressures at car motors are approximately constant, while the motor speeds must vary over a wide range, a rather large loss occurs either in motor windings, designed to aid in the regulation of speed, or else in special resistances outside of the motor, for a like purpose. Speed regulation of motors on vehicles driven by batteries is attained by changing the motor and battery connections, so that the voltage at motor terminals corresponds to the motor speed desired, and much of the loss in windings or external resistances of car motors is avoided.

Considering the loss of energy in station batteries and the loss involved in the regulation of speed for street car motors, it seems certain that battery vehicles of large capacity will receive from their motors as large a percentage of the dynamo output as street car motors deliver to their axles. If this last conclusion be correct, battery vehicles may receive a larger share of fuel energy from their motors than do street cars because of the higher economy of operation at the charging stations.

Inspection of the table on page 374 shows that the cost of land, buildings and generating plant is in most street railway systems only from one-half to one-third of the investment in rails and electric circuits, and it has been shown that the cost of generating plant and of vehicle batteries combined is only about one and one-fourth times the investment for the generating plant alone in a street car system of equal passenger capacity.

It seems certain also that the repairs on the batteries of a vehicle system can be made at an annual outlay of not more than that now necessary to repair electric lines, rails and one-half of the generating plant. There remains, then, as an unbalanced advantage of transportation with battery vehicles, a saving of about one-half of the entire first cost, and also of one-half of the annual interest charges of present street railway systems.

Copper mining once flourished in Ireland. The Ballymurtagh mine, in Wicklow County, averaged 6000 tons of copper pyrite per annum between 1840 and 1843. Desultory prospecting is going on at the present day in several localities.

Electric Lamp Fire Dangers

THERE is a common belief that electric incandescent lamps give out very little heat, and that, therefore, fire danger from them is practically non-existent. Hence it is that such lamps are frequently found disposed with much unconscious carelessness in the neighborhood of combustible materials, in shop windows, for example, for decorative effect, and the wonder is that fire losses from such use of the lamps are not more widespread.

Many experiments have been made and recorded to show how real these lamp fire risks are, and reference to some of them will well bear repetition as possibly useful in emphasizing the need of greater caution in securing illuminating effects. In one case where a lighted lamp rested against a vertically placed white pine board a spot, about an inch in diameter, and of a light-brown color, appeared after about four hours. In the case of a similarly disposed strip of well-seasoned, varnished oak, the varnish became blistered in three minutes and blackened in about fifteen. The wood had the appearance of being charred at and near the point of contact with the lamp, but was not ignited.

With a lamp encased in two thicknesses of muslin, the latter became scorched in one minute, in three minutes gave off smoke, and at the end of six minutes, when the muslin cover was removed from the lamp and fresh air reached its interior, it burst into flames. Where a lamp was laid on inflammable material, the effect seemed to be more rapid, due, probably, to the pressure exerted by the weight of the lamp. A newspaper was, in this way, carbonized in three minutes and ignited in forty-five. The lamps used were of 16-candle-power. In one instance it was found that on immersing a 16-candle-power lamp in half a pint of water, the latter boiled within an hour. Again, with a lamp buried in cotton-wool, the wool soon began to scorch and ultimately burst into flame. A lamp in contact with celluloid, fired it in less than five minutes. All these trials indicate, in a fairly conclusive way, what may be expected under certain conditions from a popularly supposed absolutely safe form of light.

Intimately associated with the electric incandescent lamp is the flexible cord connection, and in this we have a probably even more pronounced form of fire risk. In two cases, recorded some time ago, short-circuits developed in cords supporting lamps not turned on, and while the current was almost instantly cut off by the blowing of fuses, the momentary arcs were sufficient to set fire to the cords, which were oily and dirty with lint, being in a cotton mill. In both cases strands of the fine wire had probably broken and pushed their sharp ends through the insulation, causing the trouble, and both occurrences showed that however quickly current may be cut off by properly acting fuses, the heat of the arc produced, is sufficient to make the cords burn.

The Relative Disruptive Effects of Direct and Alternating Currents

IN a series of tests made by the Compagnie de l'Industrie Electrique for determining the relative disruptive effects of high-tension direct and alternating current, the results of which are given in the "Zeitschrift für Elektrotechnik," it was found that the break-down voltage for direct current was about 1.6 times that for alternating current. The alternating current was obtained from a 75-K. W., 50-cycle machine and the direct current from three 25,000-volt generators. Tests were made in the laboratory and in the open air.

The nature of the electrodes used had a marked effect on the sparking distance in air. The action at 30,000 and 60,000 volts is shown in the following table:—

Electrodes	30,000 Volts			60,000 Volts		
	D.C. distance mm	A.C. distance mm	Ratio	D.C. distance mm	A.C. distance mm	Ratio
Sphere to sphere	10	16	1.6	30.5	76	2.5
Negative point to positive disc	16	57	2.2	—	148	1.51
Positive point to negative disc	26			98		
Disc to sphere	14	34	2.4	63	117	1.85

Tests were next made on glass and porcelain insulators, the voltage being increased in each case until a short-circuit occurred between the wire and the iron support, though the insulator was seldom actually pierced.

Type of Insulator	A	B	C	D	E
Breakdown voltage with direct current	24,000	34,000	40,000	45,300	40,800
Ratio of direct-current to alternate-current breakdown voltage	1.6	1.59	1.48	1.35	1.31

Finally, tests were made on 5mm. "carton glacé" and on 20mm. marble, with the following results in the case of the former:—

Time of Electrification	Voltage	Type of current	Remarks
90 seconds	9,000	Alternating	—
30 "	11,000	"	Breakdown
120 "	9,000	"	Strong brush discharge.
15 " later	9,000	"	Breakdown
120 "	10,000	Direct	—
120 "	15,000	"	—
120 "	18,000	"	—
120 "	20,000	"	—
240 "	25,000	"	Breakdown

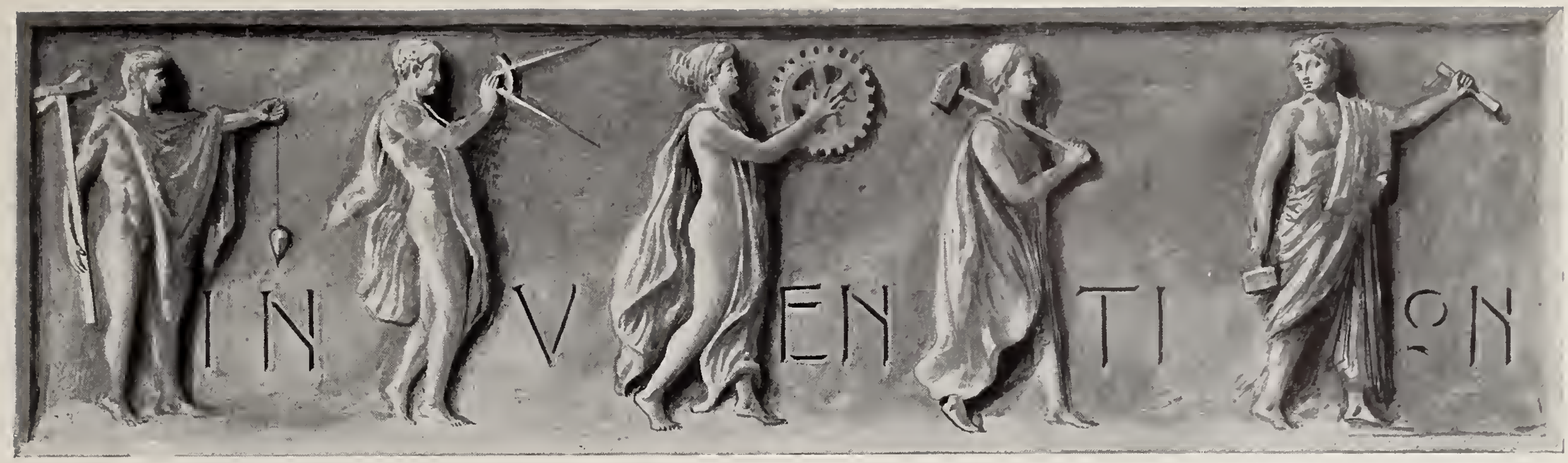
The marble plate was broken down after 75 seconds at 20,000 alternating volts, or after 120 seconds at 15,000 alternating volts. With direct current it was broken down after 15 minutes, when the voltage was increased by 5000 every 2 minutes from 10,000 up to 45,000 volts. The only disadvantage in the case of direct current is the fact that certain insulating materials are liable to become electrolyzed, but as this can only occur in the presence of water it is not of much importance.

The Electric Automobile as a Public Conveyance in Great Britain

ACCORDING to "The Electrical Times," of London, there is a rapid increase in the number of electric motor conveyances for the British public. The service established by the Great Western Railway between Slough and Windsor has been sufficiently successful for the company to propose running a similar service between Colnbrook and Slough. The North Eastern Railway Company is running a service between Scarborough and Filey, and the Great Eastern Railway is connecting Lowestoft and Southwold by a car service. Even some of the rural councils are beginning to see the advantages of the new form of communication.

The Town Council of Eastbourne are now able to give some financial results of their motor 'bus services. The report to the end of last year shows a mileage of 36,800, and that 294,922 passengers were carried. The cost per car-mile, including capital charges, was 13.6d. The cost of tire renewals is very heavy, having risen to as much as 8d. per car-mile, but this has now been very much reduced.

Mr. Shrapnell Smith, in a paper on "Motor Vehicles in Relation to Municipal Service," read recently at the Congress of the Sanitary Institute, stated that the cost per car-mile, including depot expenses, repairs, depreciation, driver, stores, sundries and supervision, will vary from 8d. to 9d. for a 16-passenger 'bus, and will be under one shilling for a double-deck car.



Electrical and Mechanical Progress

Electric Traveling Hoists

ELECTRIC traveling hoists are rapidly coming into favor and many of the more progressive shops are installing them in place of hand hoists. Besides the direct advantage of handling loads vastly quicker than the hand hoist, the electric traveling hoist has the indirect advantage of increasing the output of a shop by waking up the men. The hoist moves so rapidly that it compels the workmen to be quick in their movements, and instinctively they do their regular work more quickly. On the other hand, if the workman is using a hand hoist, he is pretty well tired out after he has lifted a load and does not return to his regular work with much vigor.

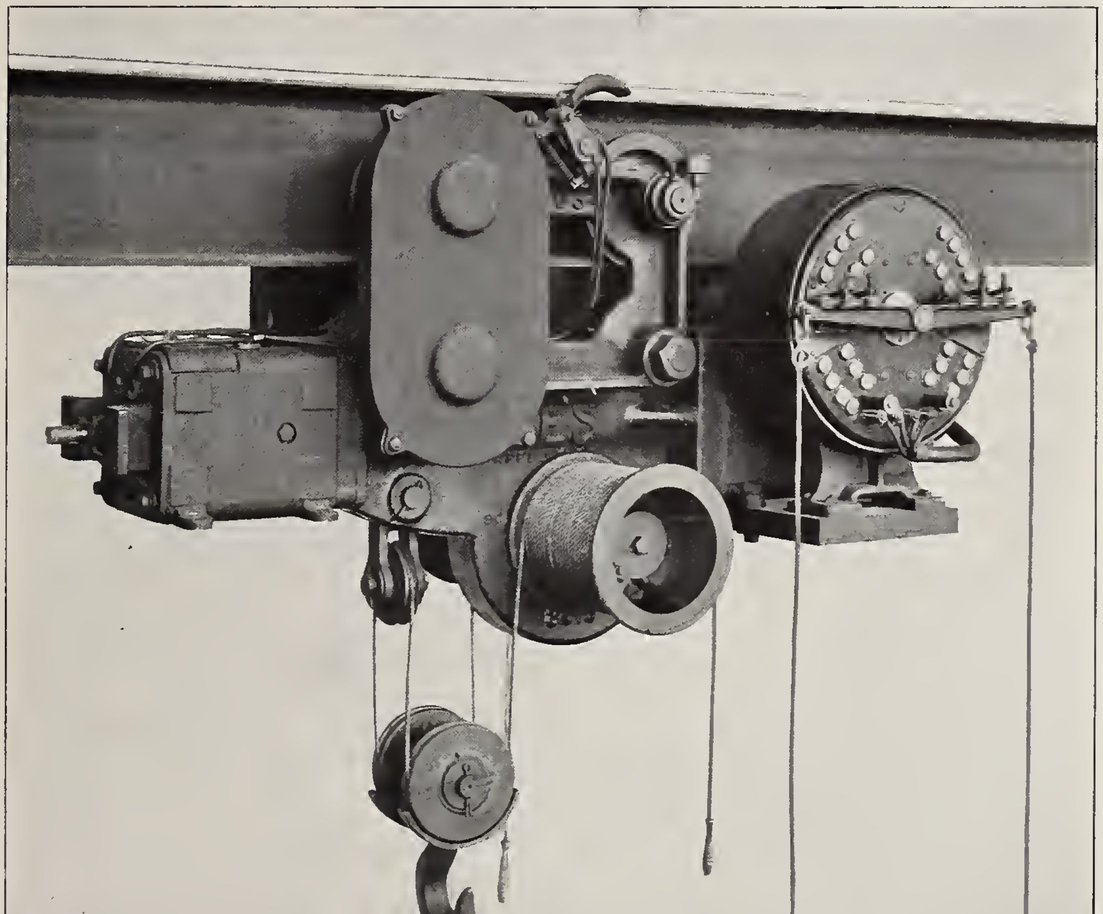
The illustration on this page shows a new type of hoist, built by the Niles-Bement-Pond Company, of New York, in capacities of $\frac{3}{4}$ to 6 tons, and may be used either as a hoist, in which case it runs on an I-beam track, or when mounted on a traveling bridge, it may be used for small capacity cranes. In the latter case, the hoists are arranged to run between the two I-beams or channels of the bridge, and the controllers for raising and lowering the hook and operating the traversing mechanism may be placed either on the hoist, on the bridge and operated by cords from the floor, or in an operator's cage attached to the bridge.

When used on an I-beam, the controllers are attached to the hoist and operated by cords from the floor. These hoists will run on straight and curved tracks and are usually provided with a separate motor for traversing, but if desired, hand traverse may be furnished, or all the traversing mechanism may be omitted and the trolley moved along the track by pushing on the load. The increased service of the electric traverse, however, much more than compensates for the slight additional cost.

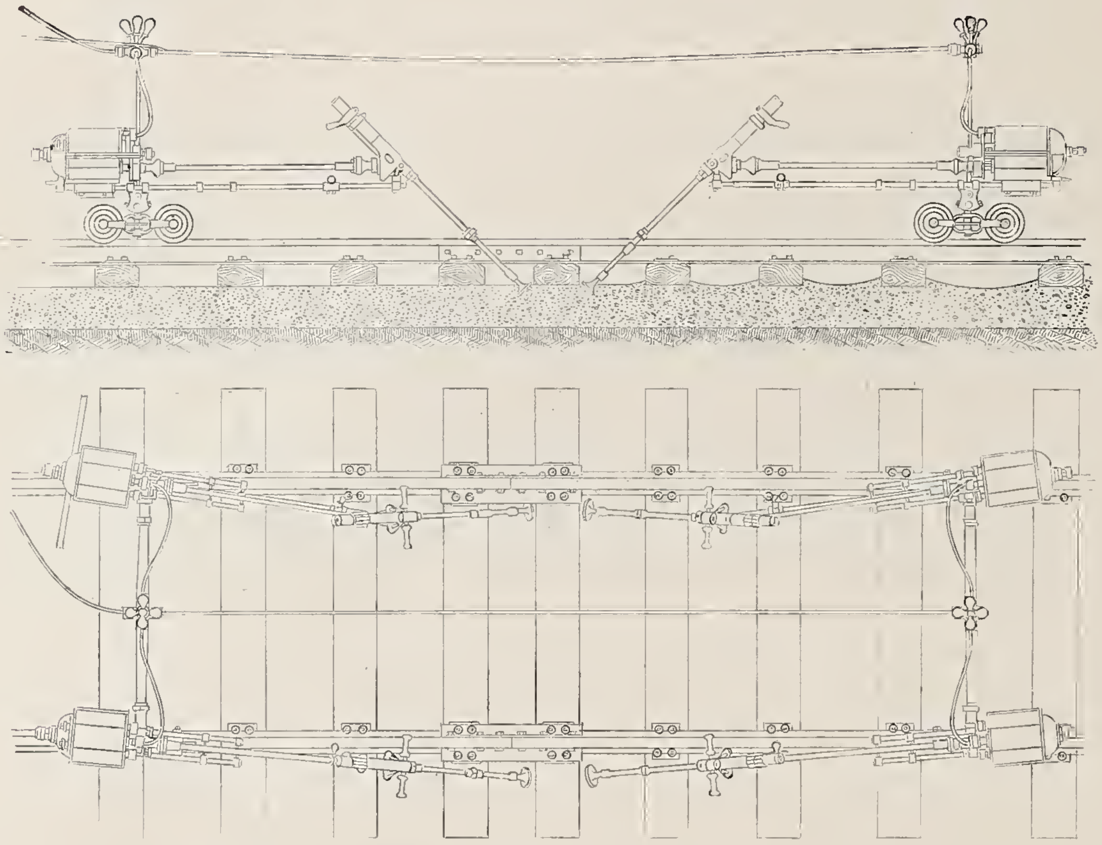
The hoist is self-contained in one heavy cast-iron frame to which the motors are attached end-on, and the power is transmitted directly from the armature shaft to the drum shaft through one train of worm and worm-wheel gears.

The traversing mechanism is also driven through one train of worm and worm-wheel gears similar to the hoisting mechanism, except that when the trolley is arranged to run on a single I-beam, a double set of transmission gears is used to connect the worm gear shaft to the truck wheel shafts. All the mechanism is enclosed in oil and dust-proof casings and is absolutely noiseless in operation.

In addition to the braking effect obtained by the use of the worm and worm wheel, a powerful electric brake is attached to the hoist motor.



AN ELECTRIC TRAVELING HOIST, MADE BY THE NILES-BEMENT-POND COMPANY, NEW YORK



AN ELECTRICAL TAMPING MACHINE, USED ON FRENCH RAILROADS

An Electric Railway Track Tamping Machine

A MACHINE for tamping railway track has replaced the method of hand tamping on several French railroads. The tamping bar is operated by a motor which receives current from a portable generating set running on the track or stationed at the side. The machine is the invention of Albert Collet, who has also constructed an electrically operated machine for boring out old ties and setting wooden dowels to hold the spikes.

The generating set, as may be seen from the annexed illustration, consists of a vertical tubular boiler and a vertical engine of 25 H. P., belted to a direct-current generator, supplying current at 220 volts. The weight of the entire outfit is about 7200 pounds.

For traveling over ordinary ground, two large, wide-tired central wheels are provided, which may be raised or lowered by turning a hand-wheel on each side. The two-wire transmission circuit for supplying current to the tamping machine is carried on A-frame supports, set up temporarily at the side of the track at intervals of 160 feet.

The tamping machine consists of an inclined shaft to which is imparted a reciprocating motion by means of the electric motor. Each of these electric motors is mounted on a frame carried by two small flanged wheels, two of these being over each rail. There are flexible joints which permit of adjusting the tamping machine to a proper position on either side of the rail. The weight of each motor and its truck is about 410 pounds.

The tamping bar operates at the rate of about 400 strokes per minute, and is held by the workman by two handles projecting at right angles to the bar. The working crew consists of six men, besides a flagman. There is a man for each of the four tamping machines, and one man to each two tamping machines to feed ballast.

Large Rotary Converters

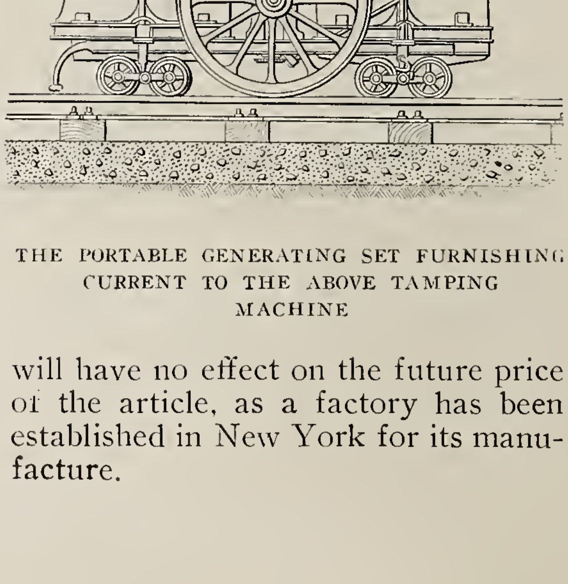
THE New York Edison Company are installing four new, 25-cycle, six-phase, 270-volt, 2000-K. W. rotary converters, built by the General Electric Company, of Schenectady, N. Y., according to the specifications of the Edison Company's engineering staff. These converters are the largest ever made by the General Electric Company and the largest ever installed by the Edison Company. The largest rotary converters hitherto installed by the latter company are of 1000-K. W. output. The total height of each machine is nearly 17 feet, and the base measures about 13 by 17 feet, occupying about 225 square feet of floor space. The armature is 12 feet 9 inches in diameter and weighs 75,000 pounds, the weight of the entire machine being 176,000 pounds, or 88 tons.

The machines will be used for the regular lighting circuits and are being put in in anticipation of a heavy demand during the coming winter months. The normal capacity of each converter is 40,000 16-candle-power incandescent lamps. For two hours daily operation 60,000 lamps can be supplied, and in the event of emergency the number may be increased to 80,000. Three of the machines are to be put in the Duane street station and one in the Twenty-sixth street station.

The Duty on Thermit

THE Board of United States General Appraisers is considering the protest by the Goldschmidt Chemical Company, Essen, Germany, and New York, against the rate of duty imposed by the local customs officers on Thermit, which is a material, the invention of Dr. Hans Goldschmidt, widely used in the welding of steel and iron. Its largest use probably is in welding electric rails, but it has also been used successfully in the repairing of steamship shafts and similar work.

Thermit is composed of aluminum and oxide of iron, pulverized and mixed in certain definite proportions. When burned in a crucible it produces in a few seconds a mild steel, which is then allowed to flow down upon the joint or fracture to be welded, uniting with the old metal to form a perfect weld. When it was first imported the customs officers classified it as a manufacture of metal at 45 per cent. and later as a chemical compound at 25 per cent. The importers are now trying to secure refunds of part of the duty paid on the basis of its being a non-enumerated manufactured article, dutiable at 20 per cent. The decision of the general appraisers, however, will have no effect on the future price of the article, as a factory has been established in New York for its manufacture.



THE PORTABLE GENERATING SET FURNISHING CURRENT TO THE ABOVE TAMPING MACHINE

Electric Smelting of Iron and Steel in Canada

ACCORDING to "The Canadian Manufacturer," the outlook in Canada is promising for the development of her iron and steel industry through the medium of the electric furnace. Large deposits of iron ore are to be found near Ottawa and the hydraulic energy for the generation of electricity is also at hand.

Dr. P. Heroult, of La Praz, France, recently inspected these deposits and pronounced the plan of their development by means of the electric furnace feasible. Dr. Heroult, as is well known, is the inventor of the electrical process of smelting aluminium, and also of an electrical process of smelting iron and steel. His opinion, therefore, ought to have considerable weight.

All through Ontario and Quebec extensive deposits of iron ore are said to be scattered, with water-powers near them, likely, thus, to afford cheap electricity, and vigorous development of Canada's iron and steel industries is accordingly expected.

Fire Rules for Electric Motors in British Textile and Corn Mills

THE Fire Offices' Committee of Great Britain have recently issued the following revised set of rules for electric motors used in textile and corn mills, and other buildings in which motors are exposed to dust and flying particles:—

1. Motors, when not in an engine room or in a separate compartment expressly set apart for their use and built of or lined with incombustible material, must be completely enclosed in an efficient metal case forming part of the designed construction thereof.

Ventilation by direct communication with the outer air or by openings in the vertical portion of the metal case protected by two thicknesses of approved wire gauze is allowed.

Induction motors may have unprotected ventilation openings in their metal cases, the superficial area of each opening not exceeding one-quarter inch, and the openings being at least one-quarter inch apart. Slip rings and brushes or any other sliding contacts must be completely enclosed in metal cases.

Inspection holes fitted with plate glass are allowed.

2. No unprotected woodwork or combustible material must be within 18 inches of any motor, and wood flooring beneath any motor must be protected by a sheet of metal.

3. The motor pulley, or other mechanical device for transmitting power from the motor, must be external to the metal case enclosing the motor. Only the shaft and the connecting conductors may be carried through into the metal case or through the wall of the compartment. No belts, ropes or other corresponding gear may be so carried.

Note:—Holes in the case to admit connecting conductors must have proper bushings, and exposed terminals must have proper protecting caps, fitted, to prevent short circuiting. Each connecting conductor must be provided with a proper switch and proper cut-out.

4. Dynamos must be treated as motors.

5. Resistances and starting transformers must be similarly situated and must be enclosed as required for motors.

6. All metal cases, tubes, etc., must be efficiently connected to earth.

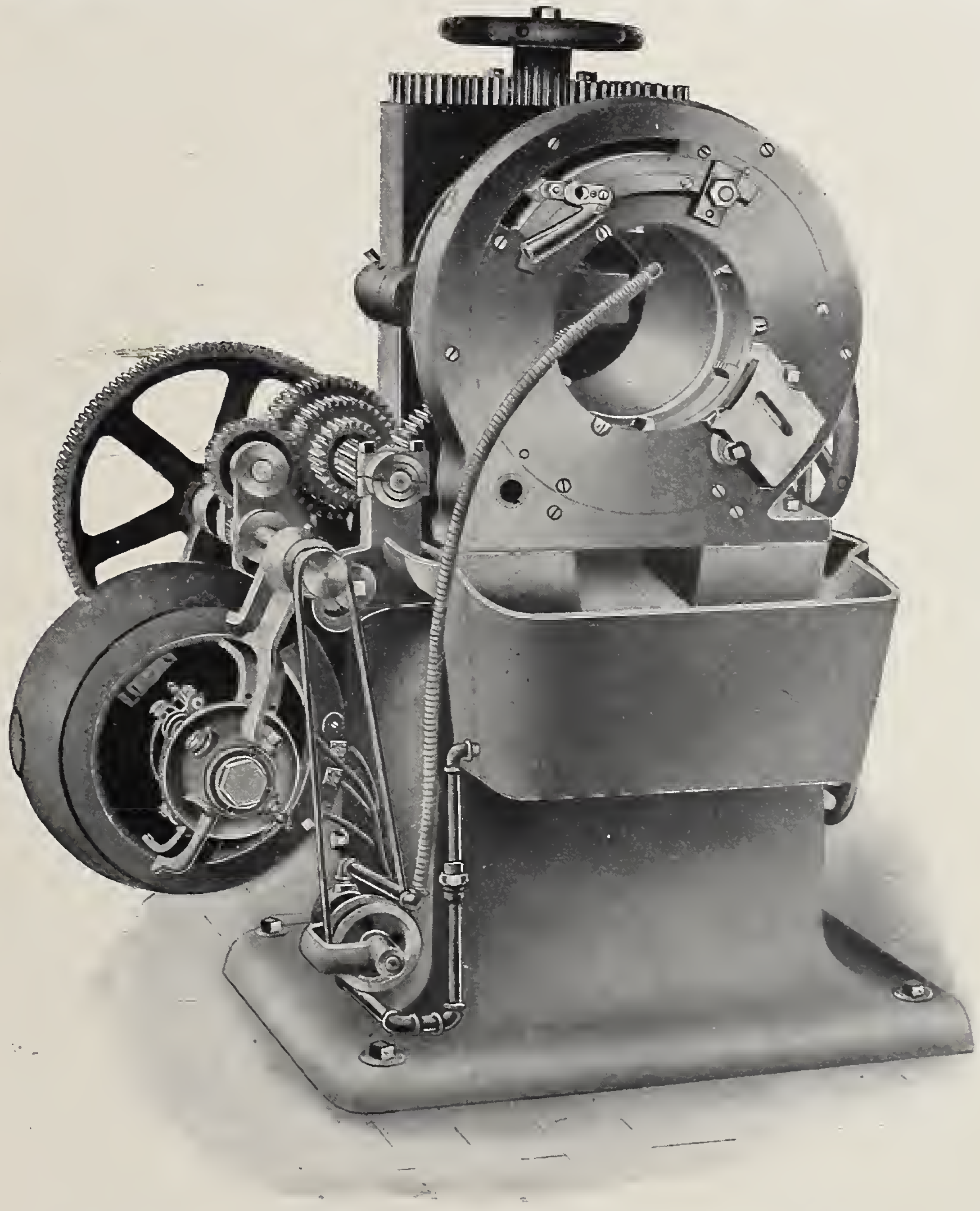
7. Motors must not be supplied with current from dynamos or conductors having an earth return.

A Motor-Driven Pipe-Threading and Cutting-Off Machine

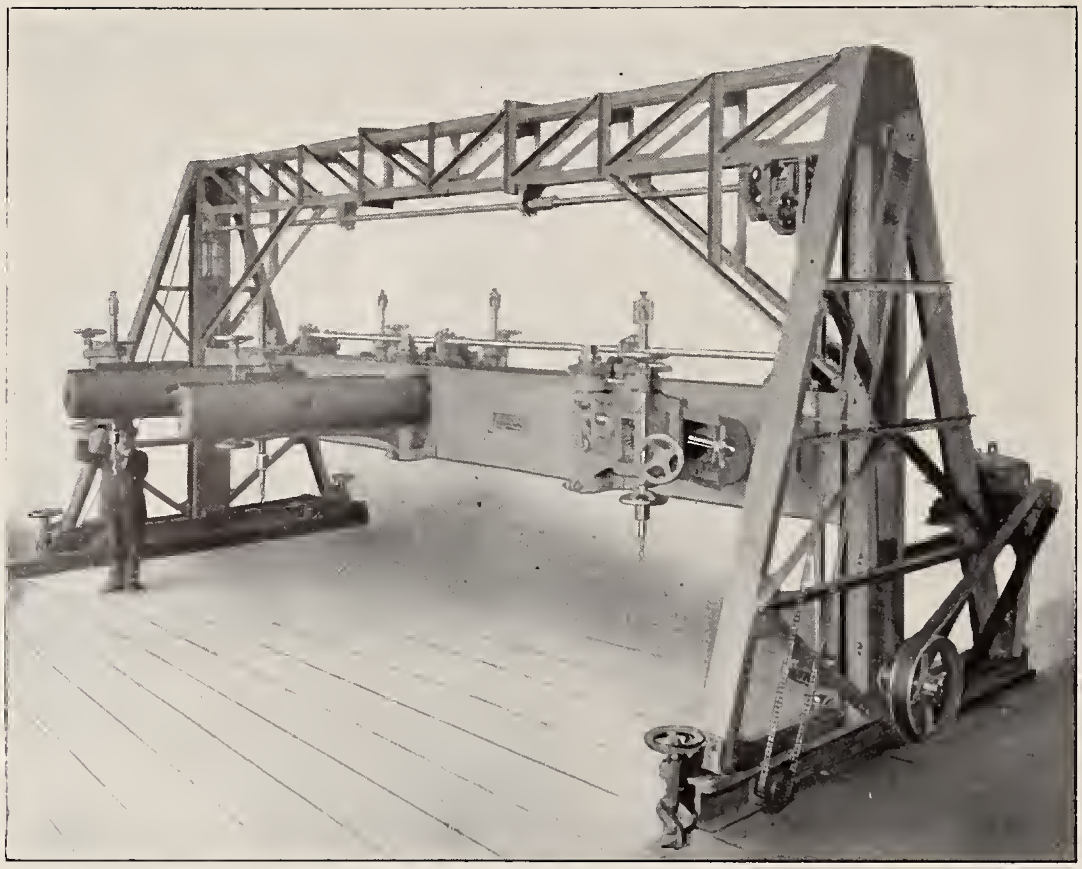
A MOTOR-DRIVEN machine, built by the Merrell Manufacturing Company, of Toledo, Ohio, for threading and cutting off pipe, is shown in the annexed illustration. The motor is of the direct-current type and runs at constant speed, variation of speed being obtained by means of an idler pinion and nested gears. The gearing is completely covered with a hood, not shown, for protection from metal chips.

The rheostat is placed inside the base of the machine and the motor is connected to a double-throw switch so that it may be run in either direction. The dies may be closed by power or by hand, with either a crank or ratchet.

The gear enclosing the dies is completely housed from dirt and chips. The chasers vary in number from five to eight, for different sizes of machines; they may be set to any size desired, and released from threading



A MOTOR-DRIVEN PIPE THREADING AND CUTTING-OFF MACHINE, MADE BY THE MERRELL MANUFACTURING COMPANY, TOLEDO, OHIO



A GERMAN ELECTRICALLY DRIVEN SEXTUPLE RADIAL DRILL, MADE BY MESSRS. HABERSANG & ZINZEN, DUESSELDORF

while in motion. The chasers may be sharpened by grinding and are readily replaced by others of any style or pitch of thread, either right or left.

The vise for holding the work is self-centering and is actuated by a rack and pinion to feed the pipe into the chasers.

The Advantages of Electric Motors Over the Steam Engine

IN a paper on "The Substitution of Electricity for Steam as a Motive Power," read before the recent International Engineering Congress, Alexander Siemens said that in comparing generally the working of steam engines with electric motors connected to a permanent source of supply, the features in favor of the latter may be summarized as follows:—

1. The most suitable size of conductors to convey the current to an electric motor can be accurately determined beforehand, with the certainty that the loss of energy calculated upon will not be exceeded.

Such conductors are generally in the form of flexible leads which are easily handled and readily adapted to their surroundings which they will not affect when properly selected and fitted, nor do they give rise to waste products that have to be separately disposed of.

2. Owing to the simplicity of their construction and the absence of reciprocating parts, much less supervision is required for electric motors than for steam engines.

3. For the same reasons the vibration caused by the working of electric motors is reduced to a minimum, and in consequence, heavy foundations can be dispensed with.

4. This again makes it possible to shift motors readily from one position to another, especially as the conductors in the shape of "wandering leads" are specially adapted for such purposes.

5. Lastly, an electric motor connected to a permanent source of supply is always ready to commence working, while a steam engine requires warming up, and very often, if the engine has a separate boiler, steam has to be raised specially, causing great delay in starting.

Against these advantages due account has to be taken:—1. Of the losses caused by the double transformation of energy; and 2. Of the interest on the additional capital expenditure.

When the current is obtained from a public supply both these items are partly represented by its price.

It will be noticed that by utilizing electric motors it is possible greatly to diminish current expenses, while the interest on capital outlay is increased and with it the charges for depreciation so that the most economical result may be expected when the electric motors can be kept working for long hours. In other words, a high load factor is as advantageous with motors as with generators to obtain a satisfactory return for the change from steam power to electric motors. This makes it possible in many cases to decide without difficulty whether it is advisable to substitute electric motors for steam engines, but there are also instances where electric motors are cheaper, although the load factor is low, and this has to be determined by carefully considering in each case all the possibilities for providing power.

Generally speaking, the experience gained hitherto makes it clear that in certain cases, notably for the propelling of ships, it is not likely that electric motors will ever replace steam engines; on the other hand it appears certain that the days of small, scattered, steam engines are over, whether they have separate boilers or are fed by long steam pipes from a nest of boilers.

Electric motors have not only replaced steam engines but they have been adopted for a great many purposes where steam engines have either never been used or have proved to be unsuitable.

The conclusion to be drawn from the consideration of the relative position which steam engines and electric motors occupy at present appears to be that it is more correct to regard the one as the supplement of the other rather than to expect a complete substitution of electricity for steam as a motive power.

A German Electric Drilling Machine

THE multiple drilling machine illustrated on this page will be of interest as an example of German practice in the design of electrically operated machine tools. It was built by the Dusseldorfer Werkzeug-Maschinenfabrik & Eisengiesserei, Habersang & Zinzen, of Dusseldorf-Oberilk. The machine was designed for drilling heavy pieces of iron work not easily moved about. The different pieces may be held together by screw clamps and the holes drilled through both at once. In this way the holes are made to match, and the center-punching of but one piece is necessary.

The tool consists essentially of two side frames connected at the top by a girder and below by a cross-rail which carries six radial arms. The distance between the side frames is about 33 feet, the cross-rail has a vertical movement of $6\frac{1}{2}$ feet, and the drills have each a maximum projection of about $6\frac{1}{2}$ feet from the cross-rail. Power is supplied by an electric motor on one of the side frames. The traveling of the machine, the vertical movement of the cross-rail and the driving of the drills are each independent of the others,

though they may be made simultaneous. Each drill may also be thrown in or out of gear by a clutch.

The motor is belted to a pulley on a short shaft, connection being made to a vertical shaft by bevel gears and similarly from the vertical shaft to a horizontal shaft over the cross-rail. The drill spindles are driven from the horizontal shaft through bevel and spur gears. Levers are provided for operating the clutch for each spindle.

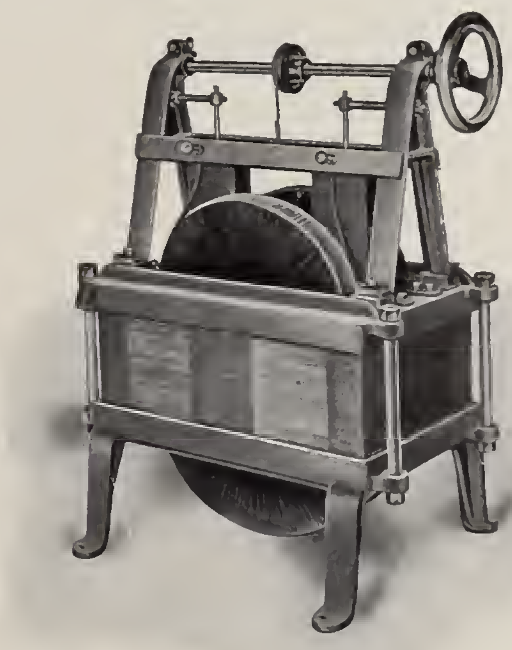
The vertical movement of the cross-rail is effected by another horizontal shaft which is thrown in and out of gear by a clutch, and connects through bevel and spur gears to vertical screws on both sides. The machine is made to travel by means of a short horizontal shaft on one of the side frames, this shaft being driven through a worm and wheel. The shaft is connected through bevel gears with one of the carrying rollers, a clutch being provided for throwing in the gears. On the axle of this carrying roller a sprocket wheel is keyed, motion being transmitted by a chain to another sprocket on the end of a third horizontal shaft in the girder. At the other end of this shaft a third sprocket is connected by chain to a sprocket on the axle of the carrying roller on that side of the machine. At the lower end of each side frame screw clamps are placed for holding the machine in a steady position on the rails.

Transformer for Thawing Out Frozen Water Pipes

IN connection with the article on "Thawing Out Frozen Water Pipes Electrically," printed elsewhere in this issue, it is of interest to call attention to the transformer outfit developed for this special purpose by the General Electric Company, of Schenectady, N. Y., and shown in the annexed illustration. This outfit can be easily connected to alternating-current circuits in the vicinity of the frozen pipes, and has been designed to withstand rough handling and outdoor service. It is compact and at the same time all parts are accessible; adjustments over wide ranges of both secondary voltage and current are readily made and the apparatus is simple to handle, portable and comparatively inexpensive.

The transformer is designed to operate on circuits varying from 2000 to 2300 volts, 60 cycles, and its secondary voltage and current may be readily adjusted from 0 to 75 volts, and from 0 to 400 amperes by means of an adjustable core or flux shunt controlled by a hand wheel and locking device.

The transformer core has three horizontal legs with a closed magnetic circuit at the ends. Flat pancake coils are threaded on the middle leg and spaced apart so as to permit an adjustable flux shunt to move up and down between the primary and secondary coils. This device constitutes a bridge arranged to shunt a varying amount of the primary flux out of its normal path through the secondary coil. When the shunt is in the lowest position it diverts the primary flux from the secondary coil, and when in its highest position permits practically all the flux to thread the secondary coil; while at intermediate positions, corresponding amounts of the flux thread the secondary coil. This



A TRANSFORMER FOR THAWING OUT FROZEN PIPES, MADE BY THE GENERAL ELECTRIC CO., SCHENECTADY, NEW YORK

construction affords a simple and convenient method of obtaining any voltage and current from zero to maximum capacity. The illustration of the transformer shows its construction and the simple method of controlling the flux shunt.

The leads of the primary coil are brought out to a suitable connection board, on the side of the transformer, on which are mounted primary switches, fuses and ammeter. The terminals of the secondary coil are brought out to heavy lugs, at the end of the transformer, from which cables can be run to the pipes to be thawed.

The outfit complete, including transformer, switches, cover and meter, weighs approximately 1200 pounds. It is mounted on four broad flanged wheels to permit its being quickly loaded on a wagon bed or sleigh. The space occupied by the transformer is, approximately, 20 inches by 30 inches, with a height of 36 inches.

The transformer has the following desirable features deserving special mention:—It is light, compact, easy to handle and operate, self-contained, free from oil and lends itself to ready adjustments from zero to maximum secondary capacity without wasting energy in a dead resistance.

The transformer, after being located close to the frozen pipe, should have the flux shunt core dropped to its lowest position, the secondary connected to the water pipe and the primary connected to the line. After closing the primary switch the shunt should be raised by means of the operating handle until a sufficient voltage and current are obtained for the particular pipe under treatment. The operating handle should then be securely clamped by means of thumb screws provided for this purpose. After the pipe is completely thawed, the shunt should again be secured at its lowest position ready for the next treatment. In thawing street mains, two adjoining hydrants can conveniently be used as terminals. Service pipes can be thawed out by using as terminals a house faucet and the nearest hydrant, the house faucet and the service pipe, or a faucet in a neighboring house.

In every case special precautions must be taken to make good connections, otherwise the water faucets, hydrants, pipes, etc., used for terminals will be burned and disfigured by the heavy current used.

Owing to various complications encountered in thawing, no definite directions can be laid down for adjusting the position of the shunt for any given size or length of pipe. The only rule which can be given is that all runs should be started with the shunt completely lowered, so that the secondary will deliver its minimum voltage and current. It has also been suggested that the transformer would prove very useful in thawing out gas pipes as well as water pipes.

The following table is compiled from data that have appeared in various periodicals. It represents average conditions for last year, and shows what may be expected in the future:—

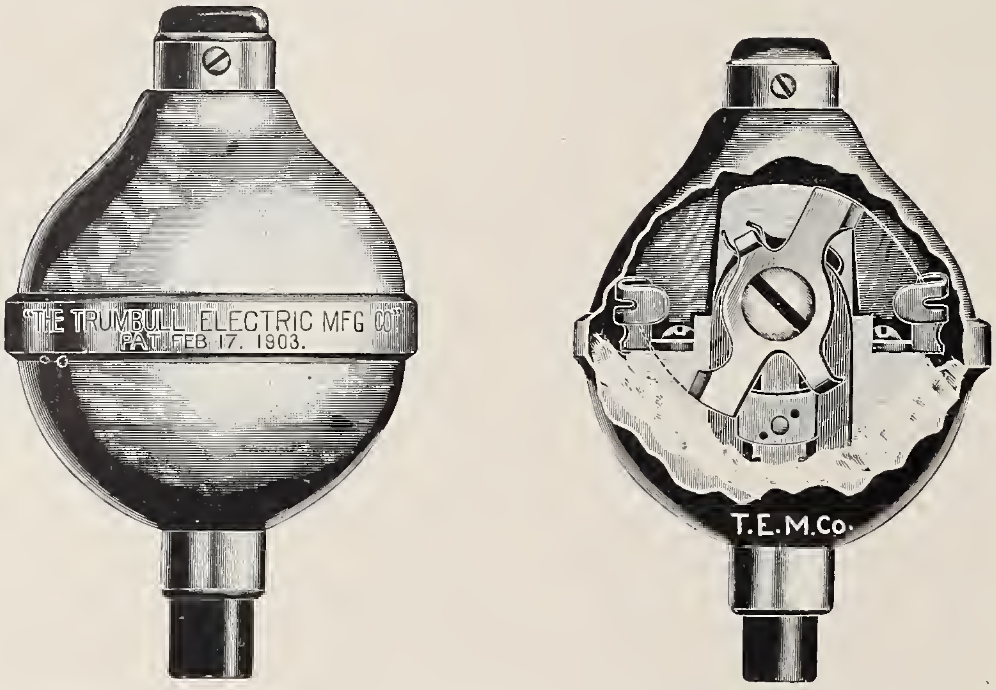
Size Pipe Inches	Length Feet	Volts	Amps.	Time Required to Thaw
3/4	40	50	300	8 min.
3/4	100	55	135	10 "
3/4	250	50	400	20 "
1	250	50	500	20 "
1	700	55	175	5 hrs.
4	1,300	55	260	3 "
10	800	70	400	2 "

The transformer is liberally designed. The large radiating surfaces of the core and coils and spacious air ducts insure cool operation under normal conditions.

While the secondary coil is rated at 75 volts and 400 amperes, for temporary operation, especially under the normal conditions of its use in win-

ter time, a very much larger current may be taken from the transformer. For instance, starting with the transformer cold on a winter's day it will be perfectly safe to take out 800 amperes for ten or fifteen minutes, and smaller currents can be taken out for correspondingly longer periods.

While the transformer is rated at 2200 volts primary, it can be safely operated at voltages up to 2500 and down to 1500 volts. It must be borne in mind, however, that as the primary voltage is reduced below its normal value, the voltage which can be obtained from the secondary will also be



EXTERIOR AND SECTIONAL VIEWS OF THE NEW PUSH-BUTTON PENDANT SWITCH, MADE BY THE TRUMBULL ELECTRIC MANUFACTURING CO., PLAINVILLE, CONN. SEE PAGE OPPOSITE

Practical Experience With Electrically Thawing out Frozen Pipes

As a supplement to the description given on the preceding page of a transformer outfit for electrically thawing out frozen water and gas pipes, the following experience notes are interesting. They are from a letter addressed to the General Electric Company by Dudley Farrand, general manager of the Public Service Corporation, of New Jersey, and tell of the experience of his company in connection with such work last winter. Mr. Farrand says:—

"The work was begun partially as an experiment, and partially to accommodate two or three good customers who were without water either at their factory or home on account of frozen service connection. But the success of the first few hours' work was so pronounced, and the feasibility of the scheme was so readily demonstrated, that it was simply necessary for us to indicate our willingness to go on with the work to produce a flood of orders which it seriously embarrassed us to know how to handle for several weeks. The only injury done in any case was caused, I think, in the first attempt, and resulted from a poor connection between the wire and a kitchen faucet, the result being that we melted off the faucet and burned out our transformer. Investigation showed that the mishap was caused by using too little resistance and too small a transformer.

"The first wagon was fitted up immediately after this with a considerable amount of apparatus for making calculations, but after a very brief experience, all the instruments were discarded and the operator simply gauged his work by the manner in which the water boiled in the barrel on the wagon, which was used as the resistance. Additional wagons were fitted up in this manner and the work carried on to the extent of our ability to spare men and wagons from other work. Most of the wagons contained a 300-light transformer wired up to a tough wooden rack, the primary fuse boxes on the side, and sufficient lengths of wire to reach an ordinary overhead circuit, the custom being to stand the wagon alongside the pole nearest the building where the pipes were to be thawed out. On the secondary side a heavy knife switch properly fused was fastened in the bottom of the wagon, and two coils of heavy wire mounted on reels were also provided.

"In the case of a single building, the method of procedure was usually to connect the primary leads to the overhead circuit, insert the primary fuses, run out the two heavy wires from the reels to the desired length, one end being connected usually through the cellar window to the water pipe, as near the cellar wall as possible, the other end being connected to the nearest hydrant or curb box, preferably on the opposite side of the street. The object was to allow treatment of the pipe at any point between the cellar wall and the street main, as there was no way of determining the exact point of interruption.

"When the pipes of two or more adjacent buildings were to be treated, the water services were simply connected in series, and as a matter of fact it was found to be just as easy to thaw several houses and took no more time than it did for one. As a matter of experiment we tried grouping buildings, to see what the result would be, and the largest number we were able to find in one location, which consisted of a row of small tenements, fourteen in number, were thawed out as easily as a smaller number, although the time required was somewhat longer.

"By having sufficiently long secondary leads, we also found it more convenient to extend the secondary than to move the wagon, and in one instance we thawed out about thirty pipes without moving the wagon The length of wire used in this case, however, was about 500 feet.

"The number of actual services thawed out, of which we have record, is as follows:—

Newark	2,000
Harrison	200
Kearny	154
Belleville	12
Jersey City	130
Hoboken	125
Orange	15
Elizabeth	7
Morristown	25
Passaic	102
Trenton	65
Perth Amboy	3
Plainfield	75
Bound Brook	50
Total	2,963

The gross revenue from this work was slightly over $12,000. The charge rendered in each case varied from $4 to $15, according to the number of connections.

"In one case a 6-inch main was thawed out simply as a matter of experiment, the time required being about three hours. The record, however, as to the amount of current required is not at hand at this writing, and I am unable to give full particulars.

"There is no doubt in our minds but that this practice of thawing water pipes can not only be made profitable to electric companies, but also that the public would be willing to pay a good round price for the service, as the expense involved in digging up frozen ground usually runs into large figures, to say nothing of the expense of restoring pavement and the annoy-

ance of broken pavement which cannot be properly relaid until warm weather returns.

"The number of services that can be handled by one outfit in a day depends entirely on local conditions of poles, wires and location of service. Our outfits consist of two men, each with a horse and wagon equipped as above, and each outfit averages all the way from 10 to 200 pipes thawed out per working day."

A New Push-Button Pendant Switch

A NEW pendant switch made by the Trumbull Electric Manufacturing Company, of Plainville, Conn., is illustrated on the opposite page.

Its distinguishing feature is that but one push-button is required to throw on and off the lights, this being done by alternate pressures of the button.

The switch proper is a 10-ampere, 125-volt snap switch of special design, positive in action and easy to operate. It is guaranteed to operate successfully 10,000 times.

The switches are finished in polished brass or nickel, other finishes being made at additional cost.

An Automatic Electric Pump and Receiver

THE annexed illustration shows a motor-driven, triplex, boiler-feed pump and receiver with automatic switches and motor starter for automatically draining heating systems and factory apparatus which depend upon a free circulation of steam for their efficiency. By doing this it serves a double purpose: first, it automatically relieves the system of the water of condensation constantly collecting in it, thus insuring a free and unobstructed circulation and, incidentally, preventing snapping and hammering in the piping, which is in many cases due to entrained water; and second, it automatically delivers this water directly to the boilers without the intervention of tanks or other commonly used devices. Not only does it relieve the system of a troublesome factor, but it introduces a supply of feed water into the boiler at a temperature impossible otherwise without the use of a special water heater.

In modern hotels and apartment houses it is necessary that machinery should operate with the least possible noise. One of the greatest annoyances is water hammer in the pipes reaching to every part of the building, but by the use of this pumping outfit such noise is entirely eliminated.

Electric pumps can be installed in locations to which it is impossible to carry any other motive power, and as this pump, by reason of its automatic control, runs only when occasion demands, no special attendance is necessary and the total cost of operation is for current actually used.

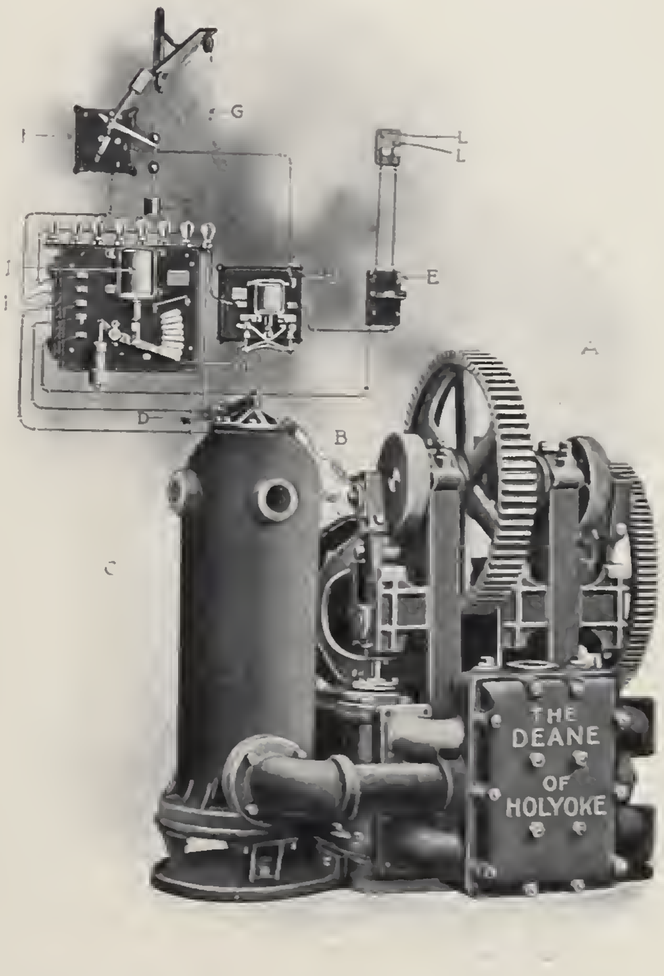
The following description will make the action of the apparatus plain:—*A* is the pump, *B* the motor, *C* the receiver and *D* a lever, operated by a pail float within the receiver, which rises and falls as the water level changes. *E* is the main-line switch, which operates by hand and is used to cut out the line when necessary. *F* is a switch operated by the float in the receiver through the chain and counter-weight, *G*. *H* is the automatic switch which admits current to the motor starter, *I*, when the switch *F* is thrown in by action of the float. *I* is the motor starter which delivers current gradually to the motor and is operated through the solenoid, *J*. *K* is the fuse block and *L* the line wires.

The switch *E* being closed, water in the receiver rises and throws in the float switch *F*, thereby turning the current through the automatic switch *H*, which, in turn, delivers it to the solenoid *J*, thus gradually pulling up the lever *I* and gently starting the pump. As the water is pumped out and the float falls, the operation is reversed and the pump stops.

The illustration shows the standard type of double-acting pump and receiver, with electrical connections and motor, as usually installed. The pump may be either single-acting or double-acting as desired, the arrangement in either case being the same. The receiver is of the vertical form, and consists of a cylindrical closed chamber or tank mounted on a bed-plate secured to the base of the pump, so that the apparatus is compact and self-contained. An opening at the bottom of the receiver is provided with a pipe connection to the suction of the pump, and the water of condensation flows into the receiver through the inlets shown near the top. Three separate inlets are provided for convenience in connecting the returns.

The receiver float is of a patented type and is a simple pail, open at the top and hung from a lever having a counter-weight so placed as to overbalance the weight of the pail. The pail is kept filled with water, and when the receiver is empty the weight of this water causes the pail to hang in its lowest position. As soon as the water rises in the receiver above the pail, the weight of the float is immediately reduced to the mere weight of the pail and the counterweight causes the pail to rise to its highest position and to throw the float switch *F* to start the pump. This style of float is very simple in construction and sensitive in operation. It is so guided as to hang in the center of the receiver without swinging, and the receiver inlets are provided with hoods to prevent the entering water from interfering with the action of the float.

The outfit is made by the International Steam Pump Company, of New York.



AUTOMATIC ELECTRIC PUMP AND RECEIVER MADE BY THE INTERNATIONAL STEAM PUMP CO., NEW YORK

A Large Water Wheel Turbine Contract

THE Wellman - Seaver - Morgan Company, Cleveland, Ohio, has been awarded by the Board of Trustees of the Sanitary District, of Chicago, the contract for the turbine water wheel equipment for the new power house of the Chicago Drainage

Canal. The contract was awarded after a competition participated in by the most noted European and American builders of water wheels.

This is the second largest installation of water power equipment contracted for in the United States; the largest single water power equipment previously contracted for being the one also built by the Wellman-Seaver-Morgan Company at Sault Ste. Marie, Mich., for the mammoth power house of the Lake Superior Power Company.

The Chicago Drainage Canal power station, which is to be located near Joliet, will be the most complete and up-to-date plant in the United States and a model of its kind in every detail. The equipment will comprise four 6000-H. P. units of turbine wheels, which will be direct connected to electric generators. There are also two exciter units of 600 H. P. each. The contract will require about one year for completion.

Trade News

Messrs. H. M. Byllesby & Company, of Chicago, who are at present constructing the gas plant at Muskogee, I. T., have been retained as engineers by the Muskogee Electric Traction Company to design and construct a railway in the town of Muskogee, with an approximate trackage of 4.7 miles.

The H. W. Johns-Manville Company, of New York, have recently placed on the market an electrical substitute for a hot-water bag. The device is called "Electrotherm," and is heated by attaching to the ordinary incandescent lamp socket.

The Thresher Electric Company, of Dayton, Ohio, supplied the electric deck winches, six in all, for the new battleship "Connecticut," which was launched recently, and also the motor generators for controlling the turrets.

The Ball Engine Company, of Erie. Pa., has received an order for a 1000-H. P. horizontal cross-compound Corliss engine for the Altoona shops of the Pennsylvania Railroad.

The Lidgerwood Manufacturing Company, of New York, have secured a contract for four electric hoists to be used in the construction of the Quebec bridge over the St. Lawrence River, and also an order for the electric shaft hoists and cages which are to form the entire elevating outfit for the shafts of the North River section of the Pennsylvania Railroad's tunnel in Weehawken, N. J., and at the foot of West Thirty-fourth street, New York City.

The Northern Engineering Works, of Detroit, Mich., reports the following sales of electric and hand cranes:—United States Lighthouse Board, Detroit, two 6-ton; Van Dorn Iron Works, Cleveland, one 15-ton; Proximity Manufacturing Company, Greensboro, N. C., one 20-ton; and others to Warren, Pa., Midland, Mich., and other cities.

The Detroit United Railway, of Detroit, Mich., has offered a prize of $200 for the words and music of a song that shall fittingly represent the remarkable progress in the extension of the electric railway.

The Burt Manufacturing Company, of Akron, Ohio, report large recent sales of their well-known Cross oil filters both here and abroad.

One of the largest of the recent engine orders filled by the Ball Engine Company, of Erie, Pa., is for two 1000 H. P. horizontal cross-compound Corliss engines, direct-connected to alternators for the Peoples' Ice, Light & Storage Company, of McKeesport, Pa.

The Keuffel & Esser Company, of New York, announce that they have received the highest award at the St. Louis Exposition, the only grand prize, Group 19, Liberal Arts (instruments of precision, philosophical apparatus, etc.), and a gold medal. Group 115, Mines and Metallurgy (instruments and equipment for underground surveying).

The Sturgess Governor Engineering Company, of Watervliet, N. Y., recently booked another order for a water wheel governor, for the Hudson River Water Power Company's plant at Spier Falls. They have also secured an order for another governor for J. & E. H. Wilson, of Pittsfield, Mass.; also one for the Pelton Water Wheel Company, for export to Brazil, and two 15-inch Sturgess relief valves and one governor for the Rochester Railway & Light Company, Rochester, N. Y., and several others.

The Northern Electrical Manufacturing Company, of Madison, Wis., recently shipped to the New York Edison Company thirty-four of its variable speed motors operating on the Northern two-wire field control system. These motors will be directly coupled to blowers for cooling the transformers in the various sub-stations of the Edison Company. There were also shipped recently nine small Northern motors to be installed in the sub-stations of the Brooklyn Rapid Transit Company. This makes a total of seventy-five Northern motors aggregating 1500 H. P. now in use by the two companies. A 60-K. W. Northern balancing set has been shipped to the New York Edison Company for the equipment of its Waterside station.

The Cutler-Hammer Manufacturing Company, of Milwaukee Wis., are distributing a sheet adapted to hang upon the wall, on which are numerous and excellent half-tone illustrations of the miscellaneous electrical devices for which the Cutler-Hammer people are so well known.

Messrs. Dodge & Day, of Philadelphia, Pa., have been commissioned by the Conkling-Armstrong Terra Cotta Company, makers of architectural terra cotta, to engineer the rebuilding and re-equipping of their plant at Philadelphia, lately destroyed by fire. Messrs. Dodge & Day have also planned an increase in the power plant of the Jeanesville Iron Works Company, of Hazelton, Pa., in which addition is contemplated the installation of a 75-K. W., 120-volt DeLaval steam turbine generator. The installation of about 400 H. P. Westinghouse motors, ranging from 5 to 150 H. P. in the new plant of the Victor Talking Machine Company, of Camden, N. J., is also being engineered by Messrs. Dodge & Day.

The Allis-Chalmers Company has won the highest honors at the St. Louis Exhibition with each of their three exhibits:—Steam engine, electrical and mining. The 5000-H. P. engine popularly known as the "Big Reliable," and the huge generator built by this company's electrical department, otherwise known as the Bullock Electric Manufacturing Company, each won a grand prize. These two machines, forming the huge unit which supplies the world-famous decorative lighting of the Exposition buildings and grounds, and which have never failed under the most frequent and most unexpected emergency loads, are so well known as the dominating features of the machinery section of the Exposition, that it is unnecessary to describe them again. The "Big Reliable" has become no doubt one of the most, if not the most, renowned power unit in the world. In the Department of Mines and Metallurgy, the Allis-Chalmers exhibit was also awarded a grand prize, the highest honor given by the international jurors. Among other features of this mining exhibit, and contributing to the success which won the highest award, are the style "K" Gates

gyratory rock and ore breakers, the Overstrom concentrating table, the Allis-Chalmers styles "A" and "B" crushing rolls, the Gates ball and tube mills, and the heavy 6-foot Huntington mill, known as the "Anaconda" type, manufactured only by this company, which is recognized as among the leaders in the engineering world. The Bullock Electric Manufacturing Company's grand prize also covered all their alternators, synchronous motors, direct-current generators and motors and rotary converters. In addition to all this the Bullock system of multiple-voltage control of motors won a gold medal.

The C. W. Hunt Company, of West New Brighton, New York, have been particularly successful at the World's Fair, two of their three exhibits securing highest awards. The Hunt "Industrial" Railway received the gold medal for narrow gage railways, and the electric storage battery locomotive built by that company received the silver medal, being the highest award for that type of locomotive.

The new isolated plant installed in the Twenty-third Regiment Armory, Brooklyn, N. Y., will contain two 75-K. W. generators made by the Northern Electrical Manufacturing Company, of Madison, Wis., direct connected to Harrisburg engines. They also have a 35-K. W., 600-R. P. M. Northern generator, belted to a Nash gas engine.

The Jury of Awards of the St. Louis Exposition has awarded the gold medal for rail fastenings to the Continuous Rail Joint Company of America for their display of rail joint products in the Transportation Building. The exhibit shows various types of rail joints produced by patented machinery controlled by the company in this country. Further acknowledgement of the merits of the company's joint is shown in the fact that over 20,000 miles of railroad track have been equipped with it within the past ten years. The company owns and operates the Albany Iron & Steel Works at Troy, N. Y. They have on the market today types of joints for tee rails and girder rails made of rolled steel. They also manufacture step or compromise joints to connect rails of different sections, and obtain a perfect surface and gauge for abutting rails. These are made of cast steel. This company is now bringing out a new type of insulated rail joint, and also an electric bonding joints to be placed upon the market. The development of the business has made it necessary to organize a company in Canada for the exclusive use of Canadian patents originally owned by them and another corporation in London, England. This appliance has already been introduced in many foreign countries. The general offices of the company have always been at Newark, N. J.

The Electric Controller & Supply Company, of Cleveland, posted a notice in their drafting-room recently to the effect that it was their intention to relieve Mr. Pirtle, who has been in charge of their exhibit at the St. Louis Exposition since the opening of the fair. As a means of selecting the man best suited for this work, they decided to inaugurate a contest among their draftsmen, allowing all to enter. The contest consisted in the writing of two articles—one on the company's improved direct motor-drive for planers and the other on their mill table controller. All articles presented were to be judged from the following standpoints:—

1. The clearest description of the functions and the operation of the various switches, circuits, etc., from an engineering standpoint, to count 40 points.

2. The best statement of the advantages arising from the use of the apparatus, viewed from the standpoint of the customer, to count 30 points.

3. The best composition from the standpoint of rhetoric and grammar, to count 30 points.

All work on these articles was to be done outside of office hours. The four judges consisted of A. C. Eastwood, engineer; R. I. Wright, assistant engineer; Harold McGeorge, general manager, and J. M. Hall, chief draftsman. Competition was keen and a number of interesting papers were presented. A decision was rendered in favor of Geo. W. Magalhaes, who was formerly a student of Case School of Applied Science and later a graduate of Columbia University. Mr. Magalhaes is now at St. Louis and will remain in charge of the company's exhibit until the close of the Exposition.

Westinghouse Awards at the St. Louis Exposition

TWELVE grand prizes were awarded by the St. Louis Exposition International Jury to the several Westinghouse companies. They were distributed as follows:—Three to the Westinghouse Electric & Manufacturing Company, for alternating and direct-current generators and motors; one to the Westinghouse Machine Company, for horizontal gas engines and steam turbines; one to the Westinghouse Air Brake Company, for air brakes and friction draft gears; one to the Westinghouse Traction Brake Company, for brakes for electric cars; one to the American Brake Company, for driver brakes; one to the Westinghouse Automatic Air & Steam Coupler Company, for air and steam couplers, one to the Westinghouse Brake Company, Ltd., London, England, for air brakes and accessories; one to the Westinghouse Company, Ltd., of St Petersburg, Russia, for air brakes and accessories; one to the Union Switch & Signal Company, for signal system, and one to the Cooper Hewitt Electric Company, for the development of the mercury vapor arc lamp.

Gold medals were also awarded to the Westinghouse Electric & Manufacturing Company for three separate exhibits, namely, complete switchboards and controlling apparatus and the application of electric motors for mechanical purposes; alternating-current, direct-current and Bremer arc lamps and arc lighting systems, and electric measuring instruments; to the Nernst Lamp Company, for Nernst lamps; to the Cooper Hewitt Electric Company, for vapor lamps for photo-engraving; to the Pittsburg Meter Company, for water and gas meters, and to the Westinghouse Air Brake Company, for the housing of the working classes. A gold medal for industrial betterment work also was awarded to the Westinghouse Electric & Manufacturing Company.

In addition to the above, silver medals were given to the Westinghouse Electric & Manufacturing Company for switches, fuses and wiring appliances; to the Sawyer-Man Electric Company, for incandescent lamps; to the Bryant Electric Company, for electric light fittings, and to the Société Anonyme Westinghouse, Havre, France, for gasolene automobiles.

A bronze medal was given to the Perkins Electric Switch Manufacturing Company for electric switches.

New Catalogues

A folder, in which are given the results of a test of a Reeves simple engine by Professors R. C. Carpenter and H. Diederichs, of Cornell University, has been sent out by the Reeves Engine Company, of Trenton, N. J. Curves of steam consumption per hour per indicated and developed horse-power for both condensing and non-condensing are given, showing very interesting results. Practically constant steam consumption from light to heavy load is a remarkable achievement for a steam engine, yet the following figures show that this

result was obtained in the tests:—Running condensing and developing 80 I. H. P., the steam consumption per hour per horse-power was 27.2 pounds; at 130 I. H. P., it was 26 pounds, and at 176.3 I. H. P. it was 27.5 pounds.

A new bulletin issued by the F. Bissell Company, of Toledo, Ohio, treats of panel boards for use with two and three-wire branches. A large variety of panel boards are illustrated and described, together with the boxes and covers for protective use. The company have also sent out a card illustrating a special dry battery.

Multiphase revolving field generators of the engine-driven type are illustrated and described in a new bulletin sent out by the Fort Wayne Electric Works, of Fort Wayne, Ind. The main features of the generators are described and shown in detail, with the exciter and rheostat used in connection with these machines.

Alternating-current generators and motors built by the Bullock Electric Manufacturing Company, of Cincinnati, Ohio, are illustrated and described in a new bulletin issued by the company.

A paper on "Commercial Alternator Design," read by W. L. Waters at the June, 1903, convention of the American Institute of Electrical Engineers, has been sent out in pamphlet form by the National Electric Company, of Milwaukee, Wis. Several illustrations of alternator parts are given in the paper, and a 1500-K.W. unit and a power plant installation are also illustrated.

A new bulletin devoted to variable-speed motors for driving machine tools has been sent out by the Northern Electrical Manufacturing Company, of Madison, Wis. Many illustrations are given of Northern motors applied to various machine tools, and their advantages are fully set forth. Curves are given showing the efficiency, speed, torque and horse-power for a 2-H. P. variable-speed motor.

Motor-generator and vehicle charging sets are illustrated and described in a new bulletin sent out by the Wagner Electric Manufacturing Company, of St. Louis, Mo. The former are intended for a continuous output, while the latter are built for developing the rated output for one hour only. The pamphlet also illustrates and describes switchboard panels for use with these machines, and tables of sizes and weights of the latter are given.

Wire rope of several varieties is illustrated in a folder sent out by the American Steel & Wire Company, of Worcester, Mass.

A booklet distributed recently by the Joseph Dixon Crucible Company, of Jersey City, N. J., is entitled "Graphite for the Motor." It sets forth the advantages of some of the graphite preparations made by the Dixon Company, calling special attention to their lubricants for the motors of automobiles and auto-boats. Their graphite cup and gear greases also are noted as well as motor chain and pipe joint compounds and yacht plumbago.

A special catalogue sent out by the Crane Company, of Chicago, is devoted to pop safety valves, relief valves and boiler trimmings. The first named comprise the various types for stationary, marine, locomotive and portable boilers, and the second are designated as water relief valves, cylinder relief and snifting valves and hydraulic relief valves. Under boiler trimmings are included the various valves, gauges and cocks necessary for the proper equipment of a boiler.

A leaf, illustrating and describing two special forms of turret lathes, to be inserted with the binder and additional pages already issued, has been sent out by the Gisholt Machine Company, of Madison, Wis. The essential difference between the machines illustrated and the company's standard forms of turret lathe, is that one has only one carriage with the turret mounted on a slide, and the other is similarly arranged, but with a gap in the bed below the face plate to permit of turning large work. Another leaf sent out by the company illustrates and describes a 64-inch vertical boring and turning mill.

Personal

Homer E. Niesz, of the Chicago Edison Company, has accepted the position of editor of the question box for the twenty-seventh convention of the National Electric Light Association. He has already begun work on it and proposes to get into communication with every central station in the country, if possible, and to reach every member of the companies interested in presenting either questions or answers. By beginning the work so early he will be able to sift both questions and answers thoroughly and to make a selection that will be of interest to the greatest number of managers.

Ernst Wiener, of the firm of Arthur Koppel, New York City, has just returned from a three months' trip to Europe. He reports that general business conditions in Germany are very good.

Frank Hedley has been appointed general manager of the Interborough Rapid Transit Company, of New York, the office of general superintendent, which he formerly held, being abolished.

H. H. Westinghouse, of Pittsburg, is down on the ballot for officers of the American Society of Mechanical Engineers, as one of the vice-presidential candidates.

Clement F. Street has has been appointed commercial engineer of the Westinghouse Electric & Manufacturing Company, to handle work in connection with steam railroads. Mr. Street is an engineer of high rank, well qualified to take charge of this important branch of the Westinghouse work. He has had a wide experience in the railroad field, gained through connection with many important interests, and his selection by the Westinghouse Electric & Manufacturing Company is a high compliment to his ability as an engineer.

J. S. Peck, until recently the transformer expert of the Westinghouse Electric & Manufacturing Company,

J. S. PECK

at Pittsburg, has been appointed acting chief electrical engineer of the British Westinghouse Electric & Manufacturing Company, Limited, and is now located at Manchester, England.

Dr. F. A. C. Perrine has opened an office as consulting electrical engineer at 49 Wall street, New York.

Prof. W. E. Ayrton was one of the group of notable British electrical engineers who visited the United States

PROF. W. E. AYRTON

recently to attend the International Electrical Congress at St. Louis. Prof. Ayrton's services in electrical interests are of distinguished kind and his name, in connection, too, with that of Prof. Perry, is fresh in the memory of every electrical student.

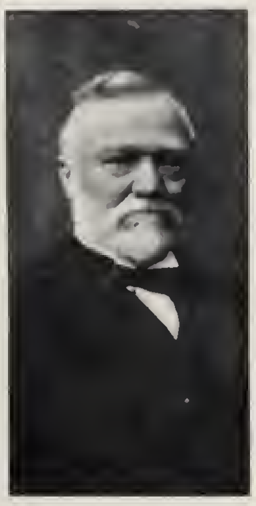
Dr. Louis Duncan, head of the electrical engineering department of the Massachusetts Institute of Technology, has resigned for the purpose of acting as electrical engineer for the New York Rapid Transit Commission and several railroad and telephone companies. Prof. Harry E. Clifford, associate professor of theoretical electricity, has been appointed acting head of the electrical department.

DR. LOUIS DUNCAN

Some time ago, Mr. J. E. Alfred, of Boston; Mr. James Ross, of Montreal, and Mr. Frederic Nicholls, of Toronto, contributed jointly a sum of money to enable Mr. Ralph D. Mershon to take up a certain high voltage experimental work, the results of which are to be made public in a paper by him. The preparations for this work, which will be done at Niagara Falls, on the New York side, are about completed and the work itself will soon be under way. It is proposed to take measurements on an experimental line up to at least 100,000 volts and possibly as high as 200,000 volts.

W. A. Blanck, having left the Arnold Electric Power Station Company, of Chicago, is now associated with the Chicago & Milwaukee Electric Railroad Company as electrical engineer, with headquarters at Highwood, Ill.

At the recent New York meeting of the Iron and Steel Institute, composed mainly of British iron and steel men, Andrew Carnegie, its president, was decorated with the Bessemer medal, the Institute's highest recognition of distinguished services in the field of iron and steel metallurgy.



ANDREW CARNEGIE

Lucius T. Gibbs, the well-known inventor and builder of many of the electric wagons and trucks operating on the streets of New York City, has joined the mechanical staff of the Manhattan Transit Company, of New York, as mechanical and electrical expert.

Frederick A. Scheffler was recently appointed a special representative of the Stirling Company, builders of the well-known boiler of that name. Mr. Scheffler will be associated with Mr. A. L. Rogers, district sales manager, at their New York City headquarters.

L. W. Serrell, of New York, well known in the electric railway engineering field, is at present giving attention to an electric water purification process from which excellent results are expected.

L. W. SERRELL

C. G. Y. King, who has for about twelve years been prominently connected with electrical interests in Chicago and with the engineering department of the Chicago Edison Company, has resigned to take over the general management of three allied companies —the Southern Fire Brick & Clay Company, the Warwick Construction Company and the Steul Chimney Construction Company, of Chicago.

John R. Freeman, of Providence, R. I., is the presidential candidate for the American Society of Mechanical Engineers, to be voted upon at the annual meeting early in December. This means practically that he will be the society's next president. Mr. Freeman is 49 years old and has had a varied engineering experience, especially along hydraulic lines.

JOHN R. FREEMAN

"Electric Automobiles in Paris," says the "Automobile Review," "bid fair to eclipse petroleum vehicles for town locomotion. Manufacturers are selling them as rapidly as they can produce them. At the Society Francaise des Electromobiles it is almost impossible to hire a machine. This popularity seems to be due to the ease of management, palatial construction, freedom from odor and suitability of the electrics for crowded thoroughfares."

A 5-mile stretch of monorail track will be built in Baltimore within the next two months for testing purposes, if the plans of a New York syndicate and the terms of a contract just given are carried out. E. L. Tunis is the holder of the patent, which has been purchased by the American Monorail Company. The motive power will be electricity, and it is said the projectors contemplate a line from Baltimore to Washington if the experiments are successful.

Cloyd Marshall (Secretary) Wm. J. Hammer C. V. Drysdale (Great Britain) Dr. Kahle (Germany) Gaston Roux (France) H. B. Smith Carl Hering

J. Holzschuch (France) Guido Grassi (Italy) Hope F. Longhborough W. V. N. Powelson (Chairman) J. E. Smith E. B. Rosa W. E. Goldsborough

THE ELECTRICAL DEPARTMENT JURY OF AWARDS AT THE ST. LOUIS EXPOSITION

The Electrical Department Jury

ONE of the most important functions which devolve upon the officers of a world's fair is the selection of the members of the International Jury of Awards. These men should stand so high in their profession and be so unbiased that their awards will be accepted both by the exhibitors and by the public as being just and wise. In order to bring about the proper findings, two juries pass upon the exhibits in each department. These are the group juries, which examine minutely into the merits of the exhibits, and when necessary conduct tests upon them.

At the St. Louis Exposition these juries were at work from September 1 to September 20 inclusive, and had at their command the splendid equipment of the National Bureau of Standards. From September 20 to September 30, inclusive, the Department Jury was in session reviewing and harmonizing the findings of the group juries. This jury consists of the chairmen and vice-chairmen of each group jury, a member of the Exposition Board of Directors and a representative of the Board of Lady Managers. The photographic reproduction on the opposite page represents the officers and members of the Electrical Department Jury, comprising W. V. N. Powelson, chairman; Cloyd Marshall, secretary; W. E. Goldsborough, chief of the Department of Electricity; J. E. Smith, director of the Louisiana Purchase Exposition; Miss Hope F. Longhborough, of the Board of Lady Managers; L. Holschuch and Gaston Roux, France; Dr. Kahle, Germany; C. V. Drysdale, Great Britain; G. Grassi, Italy; William J. Hammer, Carl Hering, Prof. H. B. Smith and E. B. Rosa.

Electric Supplies for Italy

ACCORDING to consular reports, the Italian ministry of posts and telegraphs has received authority from the Parliament to establish telephonic connections between Brescia and Bergamo, Lecco and Bergamo, Cremona and Piacenza; Genoa, Pisa and Leghorn; Naples, Foggia and Barletta, Naples, Reggio, Calabria and Messina.

The authorities of the province of Rome propose to build an electric railroad between the city of Rome and Civita Castellana.

The city council of Venice has decided to purchase a number of electric launches for use on the canals of that city.

The general inspector of the Adriatic Railroad, whose office is in Rome, has received permission to purchase 150 electric accumulating batteries.

The Adriatic Railroad Company is planning to build an electric road from Chiasso to Como and Chiavenna.

Power Consumption on Electric Railways

A CIRCULAR sent out by the International Tramway & Railway Association on the subject of power consumption on electric railways has elicited replies from forty-seven tramway companies, which have been summarized in the "Elektrotechnischer Anzeiger." The figures obtainable from the various replies differ widely. Thus, converting to English equivalents, the lowest consumption per car-mile is 560 watt-hours, whilst the maximum value is 1500 watt-hours. Even the figures per ton-mile vary between 80 and 168 watt-hours. These wide differences result partly from differences in the methods of computing the figures sent in and partly from essential differences, such as the question of gradients and curves, the distance between stopping places, the adoption of special types of motor and trailer cars in some cases, and also the variations in road condition through the frequency or otherwise of rain and snow storms in the different districts.

In some cases, also, the current used in the station workshops and lighting has not been subtracted. All these points, of course, greatly affect the consumption, so that it is impossible to decide definitely from the replies that any one tramway is more economically worked than another, but the wide variations naturally lead to the question whether further economies are not possible in many cases.

Very few of the companies are of the opinion that such economies are impossible, and most of them hope, by increased efforts, to produce a further reduction in their current consumptions. Various methods of accomplishing this are suggested. Some expect to produce a saving merely by systematic training of the drivers and inspectors; others by the introduction of the three-wire system, the distribution of bonuses, etc.

A fair proportion have gone so far as to install meters on the cars, in order to keep account of the consumptions of the different drivers, and this, so far, has led to satisfactory results. It is satisfactory to note that the different companies agree as to the reliability of the meters employed. These are obtained from various firms and differ in price from £3. 12s. to £15. 15s. each. The meters are usually fitted under the seats, but sometimes they are fixed to the inside wall of the car, or even under the car.

The frequency with which the meters are tested varies from once every four weeks to once every four months, and the inaccuracies discovered do not exceed 10 per cent. The meters are sometimes read once a day, and sometimes after each journey, or at the end of each driver's shift. Up to the present none of the companies have distributed a bonus on the strength of the meter reading, though several consider it desirable.

The general opinion would seem to be that better results are obtainable by a mechanical control of the drivers, such as that offered by the meter system, combined with the distribution of premiums, so as to give the drivers more interest in the work than would be possible simply by the careful training of the drivers and inspectors. Of course, such a system of control involves considerable expense in time and trouble, but the resulting reduction in current consumption would more than balance this, whilst at the same time it tends to produce a personnel interested in the advancement of the line.

International Wireless Telegraph Conference

THE international wireless telegraph conference, summoned at the initiative of Germany, and which was to have met on October 4, has been postponed at the request of delegations from France and Great Britain. These countries desire more time to study the questions involved. The United States Government will be notified when the date for the meeting of the conference has been determined upon. The conference was to have been held in Berlin, Germany.

At the Ohio Penitentiary Annex recently two notable instances of difficulty in electrocuting condemned men occurred. One man, according to "The Medical Record," was given an initial shock of 1750 volts, but revived, and later he received 1900 volts for eight seconds. This was run down gradually to 250 volts during fifty-three seconds; after three minutes he again revived and was again exposed to the current for two minutes. The second victim required eighteen minutes of intermittent shocks before he was pronounced dead.

A 316,000,000-candle-power search light was recently completed by the Schuckert Company, of Nürnberg, Germany. It is the largest one ever built.

Trackless Trolley Lines in Germany

By JOSEPH J. LANGER

A FREIGHT MOTOR ON THE MONHEIM TRACKLESS TROLLEY LINE

IT is just about a year since the Common Council of the town of Monheim, in the county of Solingen, Germany, passed a resolution authorizing the construction of a railless electric road, by means of which it might be possible to bring in conveniently and cheaply the raw materials necessary for Monheim's industry and agriculture, and to transport its ready products to other markets. This new means of transportation was also to serve for the conveyance of the public from and to the nearest railway station.

Monheim is a town of about 2,000 inhabitants engaged chiefly in agricultural pursuits and in the manufacture of roof-tiles and chains. Monheim is also in close connection with the famous cutlery industry of Solingen, having quite a number of scissor-grinders who call weekly at Solingen for their work and material and after finishing it return it to Solingen. These people, as well as those working in the neighboring towns, an hour's distance away, were compelled to do all their traveling back and forth on foot, unless they preferred to use the postal-wagon, which in all cases is rather expensive for the laboring class.

Persons contemplating a trip were also obliged to either walk the distance to the nearest railway station, about an hour from the town, or use the postal-wagons, unless they had their own vehicles, which, however, is a comfort that only very few people of Monheim can enjoy.

The river Rhine passes close by Monheim, but so small are the town's interests that neither freight nor passenger steamers stop there. For the same reason it has been impossible to connect the town with a railroad station by means of a branch line, so that the people, not wanting to be entirely isolated, were compelled to help themselves.

Owing to the light traffic in Monheim, and the high running expenses and initial cost of a steam railroad, this could not be considered, so that nothing else remained than to decide in favor of a trackless road operated by electricity.

The roadway connecting Monheim with the nearest railroad station, Langenfeld, is kept in very good condition and is about 23 feet wide, with a good basaltic cover about 15 feet wide. The road runs in almost a straight line, with only a few curves and but one slight incline at about the middle of the distance between the two towns. Very little building has been done along the road, which leads chiefly through an open tract of land. For several months the railless electric road has been transporting freight and passengers along this road from Monheim to Langenfeld and back, the power being furnished by the Bergische Electrical Works, of Solingen,

from their sub-station at Leichlingen, at a tension of 550 volts.

The current is conducted to and from the cars by means of two poles, placed on the top of the cars, and sliding-blocks, thus enabling the cars to give way from 10 to 12 feet. The two overhead wires are of hard-drawn copper, and are suspended about 18 feet above the middle of the road from cross wires attached to iron poles. For entering farmyards lying close to the road a coupling and a cable 50 to 70 feet long are provided to carry the current to the motor cars.

No difficulty is encountered regarding the giving way for other vehicles. When trains pass each other, one remains standing under the wires, and detaches its poles, until the other has passed by. The railless cars can be managed with the same certainty as other vehicles.

Trains are made up of an electric locomotive, shown in the illustration on page 390, and two or three cars. The locomotive is provided with two motors; each of 25 H. P. normal rating, but capable of developing a maximum of 40 H. P. A special contrivance is provided for coupling the cars so that the wheels of one car will pass over the edge of the ruts caused by a preceding car, and thus keep the road in good condition.

The cars for freight have a capacity of about 5 tons. Ordinary farmers' wagons can be attached to the end of the train, provided the ordinary tongues are replaced by shorter coupling tongues.

For passenger service a motor-omnibus, of the kind illustrated on the next page, having a seating capacity of sixteen persons, and standing room for eight, is provided. The omnibus is not symmetrically built, the front platform being reserved for the crew, baggage and fast freight; the rear platform is lower to allow the passengers to mount easily. At the terminals the omnibus is turned around. The steering is done by means of the front wheels, which can be turned 90 degrees to each side.

The cars are provided with a ventilator and permanently fastened windows. The front part of the car has a glass door to permit passage to the front platform from the interior. The inside seats are upholstered and the floor covered with a heavy cocoa mat. Under the seats of the front platform receptacles for mail matter are placed. The headlight as well as the general lighting of the cars is electric. In the event of increased passenger traffic a trailer car similar to the motor-omnibus, but of lighter construction, will be added.

The Imperial German Post Office has taken advantage of this new means of transportation, paying to the community of Monheim, which is the builder and owner of the line, $300 annually for the transportation of mail matter. After the expiration of its present contract the Railroad Exchequer also will transfer the forwarding of its official goods to the railless trolley road.

Passenger trains run at a speed of 8 to 10 miles an hour so that the distance between Monheim and Langenfeld can be covered in 20 to 25 minutes. The road is patronized to such an extent that of late a further opportunity of travel had to be provided, the present means not being sufficient for the demand.

The ordinary fare is 6 cents for the entire distance. Laborer's tickets, used on the special labor trains, are sold in the form of weekly tickets at the rate of fourth class fare on the government railroad. School tickets, good for 4 trips daily, can be had at very much reduced rates. Freight trains are run at a speed of 4 to 5 miles an hour, at intervals between the regular passenger trains, as occasion may require.

Naturally more electric current is needed for the trackless electric road than for ordinary electric cars, but this additional consumption of power by no means reaches the difference in the cost of the plant erection or running of ordinary railroads.

In connection with the matter of cost to build and operate trackless trolley roads, the figures furnished by the Berlin General Electric Company in its operation of the Haida railroad, and abstracted in "The Western Electrician," are instructive. These show that a trackless overhead trolley car, capable of holding 22 persons, used about the same electric current as an ordinary street car having room for 28 persons. With the trackless road about 25 per cent. more electric current was used than on regular street cars. It ought also to be said that the maintenance of the cars, owing to a greater wearing out of the rolling stock, and extensive need of lubricators, etc., is larger than on track cars. On the other hand, this higher cost of maintenance is met by an expense for tracks and the keeping of them in good condition.

THE OVERHEAD CONSTRUCTION

A track road for every kilometer costs from $20,000 to $30,000, while a trackless road can be built for $3,750 to $5,000. A trackless road three kilometers long, now in active operation, estimated its cost at about $4,500 per kilometer, or a total of $13,500 for the whole distance.

The total cost per kilometer is five cents, or 15 cents for three kilometers. These five cents per kilometer compare

A PASSENGER AND MAIL CAR ON THE MONHEIM TRACKLESS RAILWAY

favorably with the rate of the Great Berlin Street Car Company, which estimates its actual cost of operation at 5.17 cents a kilometer, and other street-car lines in Germany even report 6.25 cents per kilometer.

Similar favorable figures are given by Schieman in the operation of the trackless line in the Bila Valley. According to the latest reports, after a three months' operation, the cost of electric current used was double that of a track road. This greater utilization of current by the trackless trolley road was, however, only one-tenth of the sum which track roads require for interest and maintenance. A large part of the income of the trackless roads is obtained by the carrying of freight, which is a source of profit even when the passenger traffic is inadequate. Furthermore, legally considered, the trackless roads are very useful, for they are not required to meet such stringent conditions as are asked of electric track lines. As a matter of fact the streets are not at all injured by the trackless cars, but have a smoothening effect on the pavement over which they pass. It is believed that even on asphalt pavement trackless cars can be successfully used.

Cooking with Electricity

By D. A. WILLEY

At the St. Louis Exposition five hundred persons dined or lunched at mid-day on food entirely cooked by electricity, in what was termed the Electrical Restaurant. The number of patrons of this novel establishment exceeded one thousand daily, attracted by the fact that the electric current was used entirely for the preparation of solid food and beverages. Yet all the cooking was performed in a space about 4 feet in width and 20 feet in length. The various viands were so palatable that the electrical restaurant was regularly patronized by many of the visitors after they discovered the superior cuisine which it afforded.

The use of the electric current for this purpose is by no means new, but it remained for the St. Louis Exposition to demonstrate its utility on an extensive scale, with the result that the housewives who saw the system in operation undoubtedly gave it their unanimous approval. Probably a greater variety of dishes were prepared by means of the apparatus installed in the Electricity Building than have ever been served at a restaurant where the electric current was employed exclusively. In addition to the usual beverages, the menu included hot bread of various kinds, fresh from the ovens, vegetables, three or four different varieties of meats, which were not only fried, but broiled and roasted; eggs were served in the usual styles found at first-class restaurants, while a number of tempting desserts were also made by means of dishes heated by the current. In short, this exhibition demonstrated to the novice that electricity can be substituted for other forms of heat for nearly every culinary purpose.

It is perhaps needless to say that several methods are in vogue for utilizing the electric current in the kitchen. In one form it is conveyed in coils of metal, being surrounded by air or some insulating material. In another form the conductor is wound about the insulating material and made of wire or flat strips of metal. Asbestos is also coming into use as a material in which to imbed the conductor, being excellently adapted for this purpose. Enamel or glass too are being used in the more expensive forms of electric cooking and heating apparatus as an envelope for the electrical resistance wire. As is well known, the Tommasi method, which has been extensively adopted in Europe, is to place a coil of wire in a mass of acetate of sodium or hyposulphite of sodium. Several substitutes for the ordinary wire and metal strips have also been utilized with more or less success.

In the United States, electric cooking is accomplished principally by two systems, one known as the Simplex * and the other as the Prometheus. In the former system the heating element is made of wire, offering a high resistance, embedded and sealed in a film of enamel burned on the surface of the utensil, which thoroughly insulates it from the metallic portions.

In the Prometheus system the heating unit is made of a strip of mica 5 inches long and 1 inch wide, upon which is painted a compound containing sulphide of gold, prepared by mixing it with nitrobenzine and a small quantity of oil. This compound is applied to the mica with a camel's hair brush, and when dry is subjected to an intense heat for a few moments to expel the organic matter, leaving the gold burned into the mica. After the firing process, as it is called, is

* An article dealing with the simplex system incidentally, and entitled "Electric Heating; Its Field for Central Stations," by James I. Ayer, appeared in the June (1904) issue.

accomplished, the gold will be found to be evenly distributed, the deposit forming a thin, uniform layer which offers an extremely high resistance to the passage of the electric current. After firing, the next step is to attach conductor terminals to the ends of the mica, forming contact with the layer of gold. The next operation is an exceedingly important one, namely, testing the unit to determine if its mechanical structure is up to standard.

For this purpose the mica is bent and twisted. Then it is subjected to several electrical tests. Its resistance is first measured. Generally the units are made up to have a resistance of about 500 ohms. These units are turned out rapidly, the hand work being limited to the application of the gold paint to the mica. An expert can do this work so dexterously that after firing the meter will indicate a variation of only one or two ohms from the standardized 500.

In the strain tests the uniform structure of the deposited film is ascertained by causing a current of 220 volts to flow through a unit designed to be operated on a 110-volt circuit. Should there be an imperfection in the deposit of metal, it will instantly break down, due to a division of the metal caused by the burning away of the weaker portions, which results in final disruption.

If the unit passes successfully through the several tests, it is finished mechanically. Over the strip of mica having the deposited gold upon it, a second mica strip of similar size is placed to protect the film against in-

STRAIGHT AND CURVED HEATING UNIT STRIPS MADE BY THE PROMETHEUS ELECTRIC CO., NEW YORK

jury, and both are then put in a thin metal casing. Thus prepared, the units are ready to be applied to anything requiring concentrated heat with small radiation losses. In stew pans they are bent around the inner surface of the vessel; often a number of the units are coupled together, and they may be arranged in any form desired, and the heat may therefore be produced at any desired point

Both of the systems referred to have been tested with very satisfactory results. The operation of the apparatus at St. Louis, at the Natural Food Company's plant at Niagara,* as well as elsewhere, has demonstrated beyond a doubt that the percentage of heat wasted in cooking by this process is so small as to be insignificant when compared with the ordinary coal and wood stove, or ever the gas cooker. From a series of experiments which have recently been made, it is known that where electricity can be produced at the rate of 1 cent per H. P. per hour, it costs no more than gas, the price for the latter fuel being based upon the rate of $1.25 per 1000 cubic feet. This applies to the employment of the two methods in heating such articles as laundry irons.

In contrasting the results produced by the ordinary gas stove and that of the electrical range, if it may be called such, for culinary purposes, the comparison, as already noted, is greatly in favor of the electric current, for in using gas, only about 20 per cent. of the available heat is turned to cooking account. Writers on scientific and economic subjects have frequently alluded to the waste which seems to be inseparably connected with even the latest designs of cooking ranges burning solid fuel. It is perhaps unnecessary to say that the greater portion of the heat from such fuel passes into the chimney. Careful computation shows that in some instances actually less than 5 per cent. of what might be called the heat value of the fuel is available after the preparation of food where the ordinary kitchen range is depended upon.

The fact that such a large proportion of the heat units generated by the electric current is applicable for preparing the viand or beverage, naturally forms a strong argument in its favor. For the electric kitchen in service at the St. Louis Fair, an efficiency ranging from 60 to 90 per cent. was claimed. As might be imagined, the ovens for preparing bread and pastry were by far the most economical, representing the highest percentage. In short, the advantage of the electrical system from this standpoint, compared with the use of even gas, is such that no argument is needed to convince even the uninitiated of its superiority. But the electric boiler and baker have made for themselves an additional reputation for preparing meats in that these have a more palatable flavor than where they are cooked by the ordinary methods.

Much of the odor connected with the ordinary kitchen is noticeably absent in the case of electric cooking, and this is true, too, of gases and smoke. It is also a fact that the temperature of the atmosphere of the electric kitchen is not unduly raised— a very desirable feature, especially in warm weather. One reason of the popularity of the electric restaurant

INSERTING A CURVED HEATING STRIP IN COOKING UTENSIL

at St. Louis, already briefly noted, was that it was almost odorless, and while the dishes served were thoroughly cooked and kept at a sufficient temperature, the place was far more comfortable, especially in warm weather, than other restaurants about the Exposition grounds.

The large percentage of heat units which are saved by employing the electric current in food preparation is further demonstrated in roasting meats and baking bread. It has been found that an oven can be readily heated to a temperature of 400 degrees in twenty minutes. Usually the current is applied through several circuits controlled by individual switches. When the requisite temperature has been reached, only a portion of the current is required to maintain the proper temperature, and what would be waste heat in the ordinary stove or range, is saved by cutting out a sufficient number of circuits.

A Motor-Drawn Itinerant Post Office

AN innovation in the form of an itinerant post office, provided with a storage battery and motors for driving, has been introduced in Milan, Italy. In the front compartment of the vehicle the motors and battery are placed, while the rest of the space is occupied by post office employees doing the work of sorting.

The car covers a distance of 14 miles and collects letters from the various boxes, the whole time consumed being an hour and a half. The men sort and stamp the letters en route and deposit them, ready for delivery by the local postman, at the different branch offices.

---

* An article on "Electric Ovens," in the March (1904) issue of this publication deals at length with the Natural Food Company's operations.

The Nernst Lamp

The Latest Factor in Commercial Electric Lighting

By E. R. ROBERTS

A Paper Read Last Month Before the Michigan Electric Association

WHILE it is probable that there are many who are already acquainted with the Nernst lamp, not only in its general construction, but also in the electrical characteristics of its elements and the history of its development, still it may be well to touch briefly upon these points for the benefit of others who possibly have not yet given time or thought to the study of this latest factor in commercial electric lighting.

In view of the material progress which the Nernst lamp has made in the field, its history at the best is rather brief. It was early in 1898 that Dr. Walter Nernst, the inventor, in company with Mr. Henry Noel Potter, came to East Pittsburg at the request of Mr. George Westinghouse, to exhibit the invention. Foreseeing its great possibilities, and acting with characteristic promptness and energy, Mr. Westinghouse secured the patent rights for this country, and placed Mr. Alexander Jay Wurts in charge of the development work. The evolution of the Nernst lamp from its then crude, unreliable, embryonic state to the efficient, neat - appearing commercial lamp of the present day, involved the solution of serious difficulties which were encountered at each forward step. Problems were constantly arising to tax the skill of the scientist, chemist, electrician and mechanic, and the extent of what has been accomplished can only be appreciated by those who have kept in close touch with the work of development.

The first public demonstration showing that the Nernst lamp had reached the commercial stage, was made at the Buffalo Exposition in 1901.

Since the birth of the company in the fall of that year, the lamp has become widely introduced, and the results from a number of large installations show conclusively that the Nernst lamp is an important factor and represents a marked advance in the lighting field.

The "glower," or the part which gives the light, is the distinguishing feature of the lamp. It is made in the form of a small rod of white porcelain-like material, about 1 inch long and 1-32 of an inch in diameter. Fastened to each end of the glower are platinum lead-wire terminals. At ordinary temperatures, the glower is practically an insulator, but becomes a a conductor when heated to about 700 degrees Centigrade. This means, of course, that the resistance constantly decreases as heat is applied. After current starts to flow, no further heating from the external source is necessary, as the energy supplied by the current is not only sufficient to maintain the glower in an incandescent state, but causes the resistance to decrease still further with a consequent increase in current. This cumulative action, if not arrested in time, causes the current to rapidly attain a very high value, and the glower finally breaks down or flashes out. It, therefore, becomes necessary to place in series with the glower a resistance having a positive temperature correction, just opposite to that of the glower.

The resistance, which we call the ballast, consists of a very fine wire of pure iron, suitably mounted in a hermetically sealed glass tube, from which the air has been exhausted, and replaced with an atmosphere of hydrogen. This prevents oxidation of the iron and still serves as a medium to conduct the general heat from the wire. The ballast is so dimensioned throughout that with a rise in voltage above the normal operating point of the lamp, there is a rapid increase of the ballasting resistance. In figures, this amounts to about 140 per cent. for a rise of 15 per cent. in line voltage. While this effectually protects the glower against momentary fluctuations of 25 per cent. above normal lamp voltage, the ballast is liable to injury if the lamp is operated at more than 5 per cent. overload continuously. On well regulated circuits, where the lamp will not be subjected to an overload exceeding 5 per cent. for any length of time, the life of the ballast is practically indefinite and its characteristic and function is not appreciably impaired with age. This can hardly be said of the glower; like all other sources of light, there is gradual decrease in the intensity of the rays emitted. Before being used, the surface of the glower presents a smooth, white, porcelain - like or chalky appearance; after being in service, say 500 hours, this surface is rough and crystalline in appearance. it is this change in the structure of the glower, from an amorphous to a crystalline state, that is supposed to cause a rise in its resistance. The resultant decrease in candle power, from its rated value on a constant potential circuit, should not exceed 20 per cent. in 800 hours.

In the early part of the life of the lamp there is a decrease in intensity and the rated candle power value is not reached until after about twenty-five hours' run; for instance, while the rated candle power of the single-glower lamp is 50, the initial candle power would average 60. This initial excess is not contracted for and may be considered as a gift to the consumer.

Being composed of rare oxides, incapable of further oxidization, the glower does not require a vacuum, and, in fact, the presence of as much oxygen as is found in the atmosphere is necessary for its successful commercial operation. In vacuum, the glower is rendered much less stable, and requires a corresponding greater amount of ballasting resistance. Hydrogen and nitrogen have the same effects in a lesser degree, while the characteristics in air and oxygen are practically identical. Operating on direct current, the glower exhibits all the characteristics of a solid electrolyte, and its life is greatly shortened. Its life may be prolonged somewhat by reversing the current at intervals, which probably accounts for the fact that, when operated on alternating current, the life increases with the periodicity or number of current reversals.

In the automatic lamp, which is the commercial type of lamp now on the market, the glower is brought to a

conducting temperature by means of an electric heater, consisting of fine platinum resistance wires, wound on porcelain tubes, the whole being coated with a white, refractory paste which acts as a protection to the windings against the intense heat of the glower, and also as a light-reflecting surface. The heater is thrown in and out of service by an automatic cutout which, in turn, is actuated by the glower current. Fig. 1 shows the connections in a three-glower lamp.

Contrary to the practice abroad, the American company have adopted a standard glower, taking 4 amperes at approximately 210 volts, and lamps of different intensities are made by varying the number of glowers. In this connection, it may be mentioned that the manufacturers have recently developed, and are about to market, a four-glower lamp, which will have the same external appearance as the present six-glower unit. This lamp will be an equivalent, in watt consumption, to the standard five-ampere multiple alternating-current arc lamp, and should prove to be a very popular unit for general commercial lighting.

It may be seen from the accompanying table, which gives a list of the present standard Nernst units, together with their respective wattage and light intensities, that the efficiency increases with the number of glowers. This is readily accounted for by the resistance temperature characteristic of the glower, and the fact that the several glowers tend to heat each other, this mutual heating effect being, of course, greater as the number of glowers is increased.

Unit	Wattage	Mean Hemispherical Candle Power
1-Glower lamp.......	88	40.2
2-Glower lamp.......	176	86
3-Glower lamp.......	264	131.7
4-Glower lamp.......	352	185
6-Glower lamp.......	528	292.5

While the above units are operative only on 220-volt alternating current, the latter four units—viz., the two, three, four and six-glower lamps—may be adapted to 110-volt alternating current circuits by means of an auxiliary device, termed the "converter coil," as shown in the accompanying cut of lamp with converter coil. This piece of apparatus finds its greatest use in mixed installations where it is not desired to alter the line voltage; for instance, a merchant has his store lighted throughout by 110-volt incandescents, and he wishes to avail himself of the white Nernst light for displaying his colored fabrics in the show windows without disturbing the other part of his system. With the aid of a converter coil, the solution is obvious.

Unlike the incandescent lamp, the frame and connections of the Nernst lamp form a permanent structure having an indefinite life, but its perishable parts have from time to time to be renewed. Of these the ballast has a life so long, averaging about 25,000 hours, that in an organization for maintenance, it plays little part. The heater has also a very considerable life, the period averaging about eight months in ordinary use. The glower, however, like the incandescent lamp filament, has a practically definite term of use, at the end of which it would be advisable to replace the glowers whether burned out or not. Eight hundred hours are given as the guaranteed average life on 60 cycles.

Two systems of maintenance for the Nernst lamp have been employed. In the one, all the installations within a certain radius are maintained for a

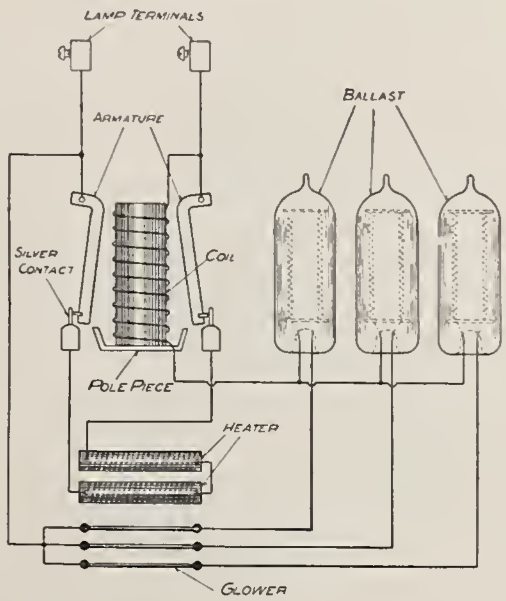


FIG. 1.—THE CONNECTIONS IN A THREE-GLOWER LAMP

fixed sum per month, from a central maintenance bureau which may be directly in control either of the Nernst Lamp Company or the central station on whose circuits the lamps are operating. This department of the lighting company is analogous to the meter department which is now becoming an auxiliary to all well managed lighting plants. Such an organization involves the services of an inexpensive class of help, consisting of an inspector, who alone, or with one or more assistants, in the case of the larger plants, operates the maintenance system, visiting all installations periodically; for example, commercial installations may be visited weekly and residential installations once per month, the user being instructed how to act in contingencies which may arise during the absence of the inspector. A complete stock of Nernst lamp parts is carried in the repair department. The work to be done here is so simple, owing to the careful provision made in the design of lamp details for easy renewal, that a boy or girl can, in a short time, acquire the necessary skill. In some central stations, where the Nernst business has not yet assumed extensive proportions, the labor item may be reduced to a minimum by having the arc trimmer include the Nernst maintenance in his regular duties.

The second system is especially applicable to the larger installations and those in isolated localities. In these cases the maintenance work may be entirely taken care of by the building janitor or electrician who has previously received some instruction and training, either at the Company's works, or from an expert repairman. Suitable quarters would be provided in the building in which a limited stock of repair parts and facilities for renewal work would be available.

The total cost of maintenance under these conditions will be comparatively low, provided the maintenance work is executed in a systematic manner, a certain portion of the day being given to a complete inspection of all lamps installed, the repairing of defective holders being afterwards done in the repair room.

Like the arc lamp, the Nernst consists of three parts, viz., the lamp body, the "holder," and the globe. The renewal elements of the Nernst lamp, viz., the glowers and heater, are mounted on the holder, which, in turn, is mechanically as well as electrically connected to the lamp body by a number of German silver prongs on the holder, which are inserted and held by friction in corresponding aluminum sleeves in the base of the lamp body, thus making the replacement of the holder a very simple matter. Without going any further into detail, it would therefore seem evident, in view of the general similarity in construction, that the maintenance of the arc and Nernst systems is much the same. In the arc system, the lamps are periodically inspected, globes and shades cleaned, carbons renewed and occasional faults in the internal mechanism or a burned out coil, repaired. In the Nernst system the requirements are cleaning glassware and replacing burned-out holders. The extra labor which is necessary for the subsequent repair of holders in the Nernst system may be counterbalanced by the extra time required in the arc system for more frequent inspection tours, the average life of the glowers being about ten times that of the carbons.

In fact, the maintenance system recommended for central stations by the Nernst Lamp Company is quite similar in its main features to the arc maintenance system of the New York

Edison Company, as described by Mr. Rhodes in his paper before the 1904 convention of the National Electric Light Association. In this connection reference might be made to a number of papers and magazine articles on incandescent lighting, in which it is shown that regular maintenance is also necessary for good results in the incandescent system, and that this, as well as all other artificial illuminants, requires regular inspection and care. The results obtained from a number of reliable sources where the maintenance of the Nernst lamp is carried out on a systematic basis, show that the cost ranges from 0.35 to 0.7 cents per K. W. hour. This, we find from available data, also represents the average cost of arc maintenance.

As to the cost of incandescent maintenance, in a most interesting paper presented by Alexander Dow before the recent International Electrical Congress, when referring to the up to date practice of the associated Edison Illuminating Companies, he says, "Under our present conditions, for each kilowatt-hour sold to customers, for use in incandescent lamps, our expense for lamp renewals is between 0.3 and 0.4 cents." Taking 0.35 cents as an average figure, and adding the indefinite item of labor, it would appear that the gap between the total cost of incandescent maintenance and that of arc or Nernst maintenance is not so wide as a great many think. Furthermore, considering the fact that the kilowatts expended in the Nernst lamps give twice the effective illumination that they do in the incandescent, the cost of Nernst maintenance per effective candle power-hour would be even less than that for incandescent lamps.

The statement occasionally heard coming from inexperienced individuals, that the Nernst lamp requires skilled labor for its successful operation, is true only in the sense that arc trimmers are skilled, and is entirely false if intended to convey the idea of expensive labor. A young man, acting as inspector and foreman at $65 per month, assisted by a boy acting as trimmer at 18 cents per hour, and a girl for the holder repair work in the station at 14 cents per hour, should be capable of handling the Nenrst business of a central station, amounting to 300 K. W. in Nernst lamps of mixed types. The maintenance bureau in the Pittsburg district sales office of the Nernst Lamp Company, which is the most extensive organization of this kind in the amount of business handled, has in its employ four boys and one girl at a combined monthly salary of $160, who handle the entire maintenance work in connection with a combined installation of Nernst lamps of mixed types, equivalent to 5100 glower units. This, of course, does not include a number of the larger installations in this district where private maintenance is employed. The territory covered by this bureau is practically all within a radius of 12 miles.

Maintenance contracts are made on a basic charge ranging from 7.5 mills to 1 cent per kilowatt-hour, depending upon the size of the installation and its location.

While these rates are figured very closely, there is a certain margin allowed for contingencies, and the organization is a paying one to the company, so that these figures are higher than the actual cost to the central station.

To sum this entire matter up in a nutshell, it is not probable that some

FIG. 2.—A NERNST LAMP WITH CEILING ATTACHMENT

of the larger central station companies would supply the Nernst lamp on their circuits on the same free renewal basis as they do incandescent and arc lamps, if Nernst maintenance is as troublesome as some would have you believe. Need I add that these companies are controlled by shrewd business men who are in the market to sell good light, and make money by so doing, and that it is hardly to be supposed that they take this stand on the Nernst question from any special feeling of charity toward the lamp or its manufacturers?

It would seem to be high time for illuminating engineers to get together and decide upon a definite and proper basis from which a comparison of the relative illuminating powers of modern illuminants may be made.

An arc lamp has both a nominal and an actual rating, the latter being based on photometric measurements, and the two differ widely. The rating of incandescent lamps is based on photometer measures obtained while the lamp is rotating on a vertical axis, while the Welsbach and flat flame gas lights are rated in accordance with measures obtained in the direction of maximum intensity. Obviously, the present commercial rating of these illuminants is absolutely unreliable because of the lack of a fair basis of comparison. There remain the mean spherical and mean hemispherical values of intensity to choose from; many say that the former should be used; others prefer the latter. If a lamp is regarded as a mere producer of light, the mean spherical value is undoubtedly the proper selection. On the other hand, if the lamp is regarded as a producer of useful illumination, opinion is gaining ground that the mean lower hemispherical value is the one desired. Comparing, for example, two lamps, each suspended near the ceiling of a reading room, the one throwing all its light in the upper hemisphere, the other all its light in the lower hemisphere; while the total amount of light given off or the mean spherical candle power, might be the same in each case, there would be no hesitancy in selecting the latter as the superior illuminant. This statement is even more true for outdoor lighting, as the upward light would be entirely lost in space, whereas in the room, the ceiling might reflect back 25 per cent. of the light for useful purposes. Again, assuming it were possible to blacken the side of the sun which is turned away from the earth, that is to say, the surface of its most distant hemisphere, its mean spherical candle power would be reduced one-half, without impairing its value to the earth as a producer of daylight. From the standpoint of utility, therefore, it is obvious that the mean lower hemispherical candle power is by far the better basis for comparison.

That the six-glower Nernst lamp is a more efficient illuminant than either the alternating-current or direct-current multiple enclosed arc, is theoretically shown by the table on page 397, taken from Prof. Mathew's report presented at the twenty-sixth convention of the National Electric Light Association.

From an inspection of the accompanying curves, which are also taken from the above-mentioned report, and a preceding report of the same committee, it is evident that for many practical purposes, such as the lighting of reading rooms, offices, stores, etc., the Nernst lamp holds an advantage which is not shown by the table on the opposite page.

Illuminants	6-Glower Nernst		Multiple A. C. Arc	Multiple D. C. Arc
Glassware	Clear Globe	Opal Globe	Opal Inner Clear Outer	Opal Inner Clear Outer
Voltage	226	226.5	110	110
Current	2.4	2.4	6.29	4.9
Watts	542	543	417	539
Power factor	1	1	.6	1
Mean hemispherical C. P.	289	258	167	229
Watts per mean hemispherical C. P.	1.88	2.10	2.53	2.25

Obviously, a desk, table or store counter under a lamp with a light distribution represented by curve 5, will receive a much greater volume of light than would be received from a lamp whose light distribution is represented by curves 1 or 2. The mean zonal efficiencies over the lower 45°-90 zone, which for the curves 1, 2 and 5 amounts to 3.02, 2.46 and 1.43 respectively, would represent approximately the actual results.

Recently, some work has been done at the Nernst lamp works in Pittsburg toward obtaining a more practical comparison of modern electric illuminants along the lines originally suggested by Mr. Wurts. A room approximately 20 x 40 feet was divided by means of an opaque curtain into two compartments, each 20 x 20 feet and both compartments furnished in an exactly similar manner, the only difference being that one compartment was lighted by Nernst lamps of different types and the other with arc,

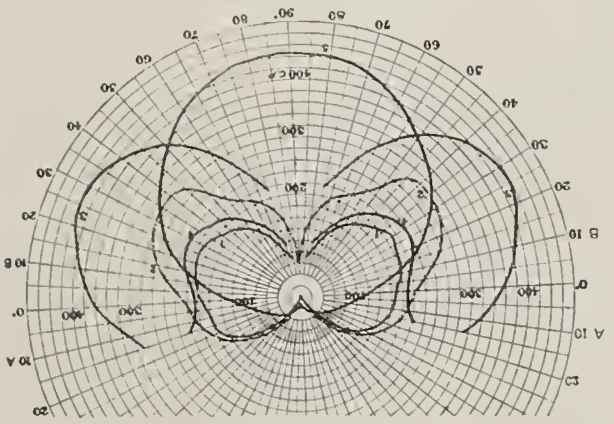


FIG. 3.—MEAN DISTRIBUTION OF LIGHT IN VERTICAL PLANE

1 110-volt A. C. constant potential arc, 6.3 amp., 417 watt.
2 110-volt, D. C. constant potential arc, 4.9 amp., 529 watt.
3 6.6 amp. D. C. series arc, 71.6 volts, 469 watt.
4 6.6 amp. A. C. series arc, 65.4 volts, 382 watt.
5 6-Glower Nernst lamp, 220 volts, 528 watt.
Arcs—Opalescent inner and clear outer globe.
Nernst Lamp—8-in. sand-blasted globe.

meridian and incandescent lamps. The illuminants in both rooms were arranged to the best possible advantage for each particular illuminant for effective illumination, each particular type of lamp being separately connected to a common switchboard, carrying an indicating wattmeter which, in turn, could be quickly connected to any particular circuit. The one room may thus be lighted by any one type of Nernst lamps, and the other by the arc, meridian or incandescent lamps at the same time, so that an observer stationed at the intersection of the dividing curtain and the wall may compare the general illumination of the two rooms. The average opinion of a number of observers as to the respective merits of the lamps, was based upon the general appearance of the rooms under the illumination furnished, and special visual tests in each room. While the work is yet in an uncompleted state, the results so far point to the following conclusions:—

The one-glower Nernst is equivalent in effective illuminating power to 3 16-candle-power incandescent lamps.

The three-glower Nernst is equivalent in effective illuminating power to $9\frac{1}{2}$ 16-candle-power incandescent lamps.

The six-glower Nernst is equivalent to 20 16-candle-power incandescents.

The six-glower Nernst is somewhat better in effective illuminating power than the $7\frac{1}{2}$ ampere multiple alternating-current enclosed arc.

The new four-glower Nernst is equivalent in effective illuminating power to 6.6 ampere multiple alternating-current enclosed arc.

APPLICATIONS AND PROGRESS

It is now generally conceded that the color of the Nernst light is closer to that of sunlight than that of any other illuminant, and instead of attempting, at this time, to support this statement by a discussion of spectroscopic data, it may be mentioned that the directors of the Fine Arts exhibit at the Louisiana Purchase Exposition selected and are now using the lamp to light the art palaces. This selection was the result of a series of careful, practical tests to determine which of the modern illuminants was most effective in bringing out the colors applied to the paintings by the artists when sketching from nature by daylight and in providing the most pleasing general effect. These same remarks apply to the recent decision of the Art Committee of the Albright Art Gallery in Buffalo, to use the Nernst lamp in their handsome new structure. Naturally this advantage in color, combined with those of steadiness, economy and neat appearance, would also tend to make it especially adapted for store lighting, and one need not be an optimist to foresee a promising future for the lamp in this particular field. That the lamp is becoming useful to the central station, as a competitor of gas mantle burners, especially in the haunts of artificial gas, is practically demonstrated on the circuits of large lighting companies in the country. Not only is this true for interior work; several Nernst installations for street lighting have been made wherein the one-glower lamp has been successfully used in competition with single burner gas lamps. With reference to street lighting in general, suffice it to say that careful estimates show that the Nernst system involving the use of the six-glower lamp compares very favorably in the results obtained, as well as in cost of generating equipment and maintenance, with a modern alternating-current or direct-current series arc system. As compared with the alternating-current arc system, the Nernst system would have the advantage of 100 per cent. power factor tending towards better regulation. It is also fair to expect a more compact and simple station equipment than would be required in either of the arc systems, particularly in the case of the direct current.

While there have been close on to 400,000 glower units placed in service in the United States for various classes of lighting, it will not be attempted at this time to set forth the special adaptability of the Nernst lamp for each class of commercial lighting. With the exception of stage and electric sign lighting and a few other special uses for light energy, the legitimate field of the Nernst is practically identical to that covered by other modern illuminants.

Since the policy of using the central station as a medium for marketing its product was instituted by the company in the early part of this year, over 100 central stations have adopted and are supplying the lamp on their circuits. Classifying this list with respect to the size of the different cities represented, we find that the illuminating companies of three cities of over 500,000 population, four cities of over 250,000, three cities of over 100,000, seventeen cities of over 25,000 and seventeen cities of over 10,000 population have adopted the lamp. Of the total number, about 20 per cent. have seen fit to furnish free renewals, putting the lamp out on a flat rate contract basis.

Electric Safeguards for Ocean Travel

By GEORGE L. CLARK

THE danger to navigation from fogs and icebergs on the North Atlantic has occupied the attention of scientists and the shipping world for more than a quarter of a century. With the increase of the fleet of ocean steamers that ply between Europe and America, the danger multiplies rapidly. So far the numerous inventions for aiding the navigator in making his way through the dense fog banks have not satisfactorily released him from grave responsibilities, though the blame is not to be laid on him if an accident happens, for the thick curtain of fog makes life on the ocean perilous and uncertain under the most favorable conditions. It is often luck rather than good seamanship that averts collisions.

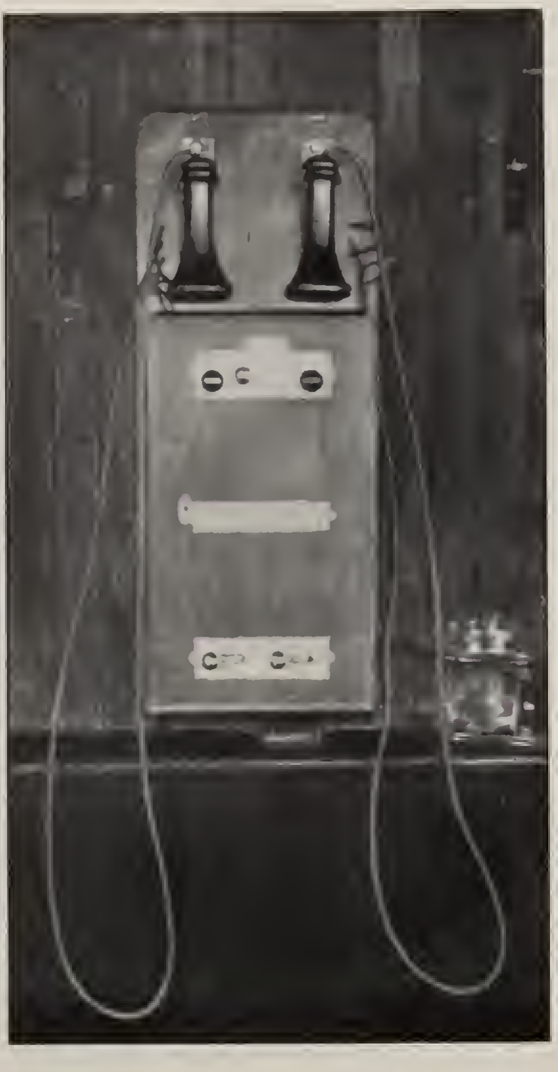
Sir Oliver Lodge has succeeded in dispersing fog within a radius of 50 or 60 yards from a source of static electrical discharge, but any attempt along the same line on the heavy fogs common off Newfoundland will hardly meet with much success. Fogs are, therefore, likely to remain with us indefinitely, and all that science can do is to minimize the danger by the invention of warning apparatus that will foretell the presence of an iceberg or locate the position of an approaching ship.

Wireless telegraphy and sound signalling through the water have promised to eliminate to a considerable extent the dangers of North Atlantic travel, and the installation of both systems for communication between passing ships and the shore has proceeded with commendable activity in the past year. The number of ships carrying wireless telegraph apparatus has steadily increased, and it will probably not be many years before it will be required by law for all ships to be thus equipped.

The United States Government, too, is rapidly equipping its lighthouses and lightships with wireless telegraph instruments, so that passing ships can be reported, and their progress from

AN ELECTRIC SOUND SIGNALLING TELEPHONE IN A STEAMSHIP'S PILOT HOUSE. INSTALLED BY THE SUBMARINE SIGNAL CO., BOSTON

one part of the coast to another indicated. The lightships off the fog banks can thus communicate the dangers ahead to each passing ship. Each one entering the fog will be informed of the presence of another steamer ahead, with the hour of its passing, the rate of its steaming and its probable course and location. The ocean track will thus be kept under the constant supervision of wireless telegraph dispatches much like the tracks of a railroad system with the ordinary telegraph. Each steamer passing an iceberg will report its location to other ships or to the wireless stations along the coast and lightships anchored off shore, and it will thus be possible to warn incoming or outgoing steamers in advance.



A SOUND SIGNAL TELEPHONE OUTFIT ABOARD SHIP

The United States Weather Bureau has already organized a special department to study fogs and icebergs on the high seas, and in conjunction with the Navy and Lighthouse Board, efforts will be made to chart icebergs as they float down from the north in the spring or summer seasons. A derelict to-day has little chance to cause trouble on the high seas, owing to the precautionary methods taken by the Government. When a derelict is once reported, the latitude and longitude, with the direction and speed of its probable drift, are given to every outgoing steamer, and shortly incoming steamers will be furnished with the same information by boats outward bound. The same plan with regard to icebergs is a part of the present scheme of the United States Navy and Lighthouse Board. It is possible to locate and chart drifting icebergs by means of wireless telegraphy, and to warn ships of their presence.

The use of submarine sound signalling for communicating with passing vessels will supplant the wireless telegraph systems established on many of the lightboats and lighthouses. The Canadian Government is installing thirty stations in the St. Lawrence River and off the coast of the maritime provinces with the new submarine sound signalling apparatus. The United States Government has also been investigating and experimenting with the system. The first trials, made at the Pollock Rip Shoals lightship and the Vineyard Sound lightship, off the Massachusetts coast, proved so successful that other experimental stations were equipped with the instruments. Experimental stations are soon to be established at the lightships at Nantucket Shoals, Fire Island, Sandy Hook, Overfalls, Brenton's Reef, Cornfield and Portland.

The practical use of submarine signalling is of more recent date than wireless telegraphy, but experiments have been made with this form of communication for years past. The practical success of the system within a radius of 10 miles from shore or a lightship at sea has made possible a new method of protection of ships from dangers at sea.

As in wireless telegraphy, submarine sound signalling presupposes the equipment of all vessels with telephone apparatus for receiving and sending messages. Small portable apparatus for receiving submarine warnings has been made for fishing boats. Equipped with these instruments, the fishing smacks on the Newfoundland fog banks could be warned of the presence of an approaching steamer long before the zone of danger was reached. At a distance of nearly 10 miles the telephone bell on the small fishing smack would faintly tingle, and as the steamer approached nearer, its direction could be ascertained. The fishing smack could thus either sail out of the course taken by the steamer or persistently sound the warning fog-horn. When it is realized that many fishing smacks are lost every year through collisions with steamers, the benefit of the new submarine signalling system can be appreciated.

The system is based upon the conductivity of sounds through liquid mediums. Sound travels faster through water than through the air. The sound vibrations made by a ringing bell under water are caught up by

AN ELECTRIC SOUND SIGNAL BELL LOWERED UNDER WATER

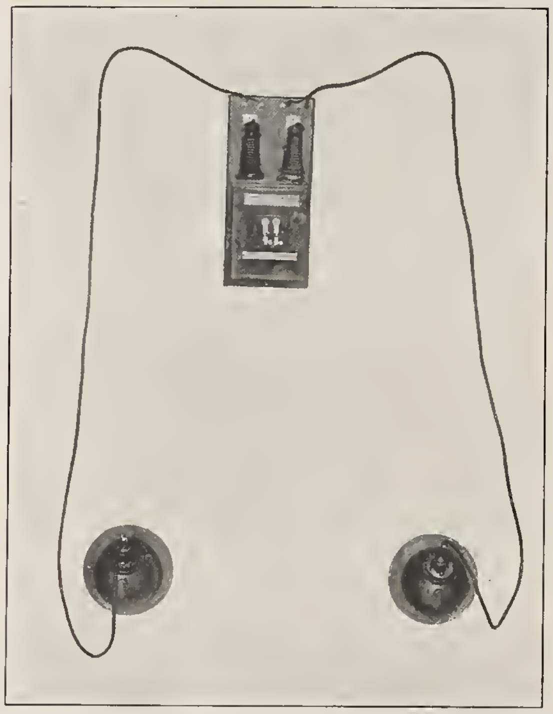
a receiving apparatus and then transmitted electrically to a small telephone. The installation of the apparatus on a lightship is made by hanging the large sounding bell through a well in the center of the vessel. The bell is located about 25 feet below the bottom of the vessel, as this distance has been found to be the best for long-distance transmission of the sound waves. An operating chain or wire connects with the bell crank of the hammer. The upper end of this chain or wire is attached to a piston which is operated by compressed air from the lightship.

The vibrations of sound started by the ringing of the bell under water travel a distance of from 5 to 10 miles, according to the size of the bell and the stroke of the hammer, and are then collected by a receiver. So persistent are the sound vibrations that they will pass through the iron sides of a ship and still prove effective. The receiving apparatus for vessels is accordingly clamped in many cases to the inside surface of the outer iron or steel hull.

From the receiver the sound is transmitted electrically to a telephone in the pilot house. When the sound waves, started by the striking of the distant submarine bell, reach the side of the ship's hull, they are communicated to the liquid inside of the receiver and electric pulsations are produced which reproduce the sound in the telephone receiver. In order to ascertain the location of the sound, two receivers are necessary, one on either side of the ship. Sound under water travels, as in the air, in all directions, but it is much louder on the side of the ship nearest the bell. Thus by listening alternately to the telephone on the port and starboard side it is easy to tell from which direction the signals are approaching.

Experimentally the accuracy of the new system of submarine signalling has been demonstrated, and passing ships have kept in constant communication with the lightships for nearly 10 miles. By turning the ships around in the fogs off the coast the direction from which the sounds approached was so easily and accurately ascertained that no room for doubt was left in the minds of the navigators.

In foggy weather sounds passing through the air are very deceptive. It is impossible to locate them with any degree of satisfaction. The ear is not to be trusted in such cases, for often the sound appears to travel most easily in a roundabout way and makes a more distinct echo on the opposite side from the fog-horn or steamer approaching. This peculiar acoustic property of the foggy atmosphere has caused the death of many a mariner. Trusting to his ears to detect the course of the approaching steamer, he has steered directly into the path of danger. This deceptive nature of sound on the water is so well recognized to-day that navigators never



TELEPHONE APPARATUS WITH ATTACHMENTS TO INSIDE OF BOAT HULL

place any reliance on their hearing independently of other determining factors.

Submarine sounds act quite differently. Foggy or heavy weather makes no difference to the under-water sound vibrations. They travel uniformly in all directions at all times. It matters little which way the wind is blowing or how heavy the thunder is crashing. The sound waves announce their presence underneath the hull when storms are raging above so that wireless telegraph messages cannot be transmitted or received. It is very apparent, as a result, that a ship equipped with submarine sound signalling apparatus can keep in direct communication with the shore or lightships along the coast in any kind of weather. There is no other system that is so independent of weather conditions.

To make the system more useful, a code of sound signals is arranged so that messages can be sent back and forth between lightship and passing steamer. At 8 or 9 miles the tones of the bell are rather muffled and indistinct, but clear enough to indicate that the ship is approaching. At 6 or 7 miles, even in a heavy storm of wind and rain, or when passing through a bank of fog, the sounds of the bell are distinct and metallic in tone. At 3 and 2 miles the musical notes of the bell ring clear. Even at such a distance any steamer could be warned of danger in time to turn about or stop.

The small portable submarine signalling outfit for fishing smacks will probably be the means of saving many lives every year on the banks off Newfoundland. The bell of this portable outfit is suspended over the side of the boat by means of a rope, and a second wire or rope is used to strike the hammer. A water-tight globe contains the electrical apparatus for receiving the sound waves, and from this runs an insulated cable to the receiver above. The bell and globe are lowered overboard to a distance of 25 feet. The sound from another bell strikes the spherical receiver, which instantly transmits it to the telephone above. Two boats similarly equipped can thus be kept in constant communication with each other in the heaviest and foggiest weather.

Electric Headlights on Indian Trains

SOME of the new locomotives brought into service by the North Western Railway, of India, are fitted with powerful electric headlights of American manufacture. The equipment, according to "Indian Engineering," consists of a turbine generator mounted on top of the boiler, and two projectors mounted on the head of the engine and the rear of the tender, respectively. The projectors are capable of movement over a wide arc both horizontally and vertically by a quadrant and a screw elevating gear, both of which are operated from the cab of the engine.

The reflectors are so shaped as to throw a parallel beam of light, which, under favorable circumstances, will illuminate a straight track to a distance of three-quarters of a mile. The lamp is of a peculiar pattern, the negative electrode being of copper, while the other is of solid carbon.

The turbine generator is a very compact apparatus, a small turbine being connected through a flexible coupling to a four-pole generator furnishing direct current at a normal pressure of 35 volts. The lamps are controlled by a double-pole switch placed in the cab, the connections to the generator and lamps being run in wrought iron tubes.

By the formation of a short circuit in one of the junction-boxes in an electric main in Melbourne, Australia, every city fire brigade received an alarm. Every telephone-bell in the vicinity was rung, whilst 1500 indicator-shutters dropped in the exchange.

THE ELECTRICAL AGE

Established 1883

Volume XXXIII Number 6
$2.50 a year ; 25 cents a copy

New York, December, 1904

Entered at the P. O. as 2d-class matter Copyright, Louis Cassier

DESTRUCTION OF A BATTLESHIP BY AN ELECTRICALLY OPERATED SUBMARINE MINE

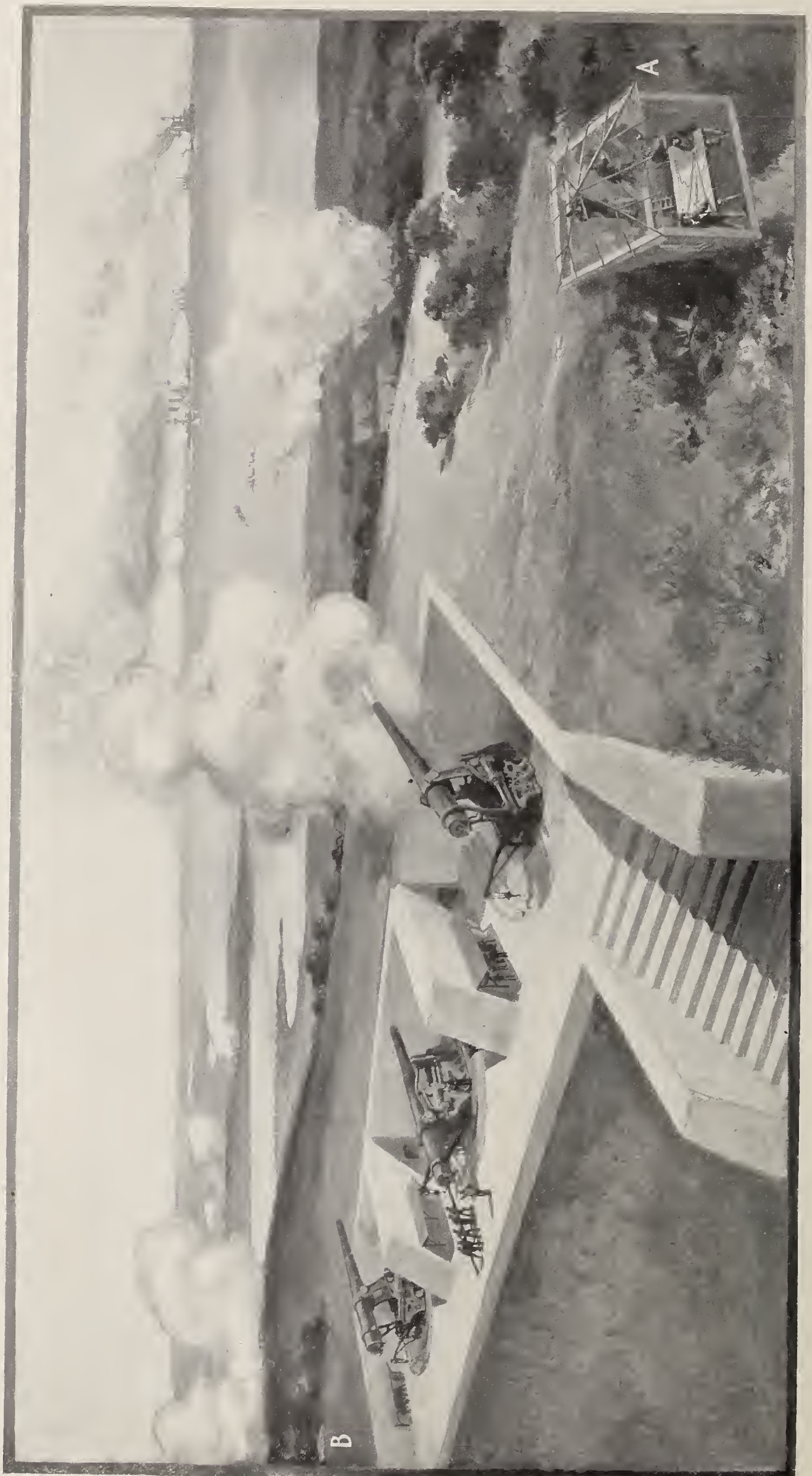
Electricity in Sea Coast Defense

By M. C. SULLIVAN

THE defensive powers of modern seacoast fortifications have been made possible only by the application of electricity, and as the limit to the effective use of this great agent of light, power and communication cannot be foreseen in military work, it is reasonable to expect that the future holds in store as great achievements for the military electrical engineer in his chosen field as those accomplished by his brother engineer in industrial life.

The permanent seacoast defenses of the chief ports of the United States, from Portland, Maine, along the Atlantic Coast to the Gulf of Mexico, and along the Pacific Coast to Puget Sound as now equipped for repelling naval attack, are unrivaled by any in the world in design, construction and equipment. The beginning of this modern plan of coast fortifications was coincident with the invention of the great rifled cannon of the disappearing type.

This evolution represents a development of about fifteen years and, when finished as planned, an expenditure of $60,000,000. It is estimated that about 1 per cent. of this amount will be required to purchase electrical apparatus and equipment. Six hundred thousand dollars are so small a portion of sixty million that a layman may easily presume that what they represent is of slight importance compared with the purchasing power of the balance of the great sum. Yet if there ever was a case of the tail wagging the dog, it is presented in this instance. Discard that which the $600,000 procured and that remaining, the cost of which was more than $59,000,000, would be almost if not quite as useless as so



FIRE CONTROL OF A MODERN FORTRESS. SEE PAGE 405

Drawn by L. A. Shafer.

A LOOK-OUT STATION ON THE LAND SIDE OF A FORTRESS

much scrap iron. Do away with electricity and you make impossible the effective handling of the great guns and the ammunition that supplies them. Lighting, communication and numerous other vital essentials are in modern seacoast fortifications wholly dependent upon this all-important agent.

Considering the varied and important uses to which electricity is now put in warfare, it seems at least strange that its application to military work is of comparatively recent date. Its use in seacoast fortifications constitutes one of the most highly specialized functions of our military administration. This being the case, it is all the more remarkable when one considers that there are few of the many uses to which electricity is put in warfare of which the worth was not proven in industrial work long before its application to military work.

Although electricity has done more than any other single element, except the huge rifled disappearing cannon, to promote the effectiveness of our permanent seacoast defenses, it was not until 1898 that the electrician was specifically recognized as such by the United States Army. At the outbreak of the Spanish war in that year, the United States Congress enacted a law requiring that two-thirds of the Volunteer Signal Corps membership should consist of electricians or telegraph operators. In 1899 an enactment by Congress, applying to the regular army, establishing the rank of electrician sergeant, became a law. Subsequently, in the same year, the War Department established at Fortress Monroe, Va., a school for training electricians for service in our seacoast defenses. Graduates of this school, on being assigned to regular duty, have the rank of electrician sergeant. This school, greatly enlarged, has since been transferred to Fort Totten, on the north shore of Long Island, N. Y. In 1903 further enactment by Congress relating to the regular army augmented the force of electrician sergeants, and also provided for the establishment of a body of twenty-five electrical experts to be known as master electricians.

The disposition of this new force in the regular army is somewhat as follows: One or more electrician sergeants, as the case may require, are assigned to each fort and a master electrician is detailed to each artillery district, which in most cases includes several forts. Following the initiative of the National Government, the State of New York, in 1904, by an act of the Assembly, created the rank of electrician sergeant in the National Guard, and provided that four such experts shall be attached to each regiment of heavy artillery in the State. Thus it will be seen that the National and State Governments have accorded the electrician a permanent place in the national defensive forces. There are schools at Fort Myers, near Washington, D. C., and at Fort Wood, New York Harbor, which are officially designated by the War Department as signal schools. But these in reality are electrical schools, the instruction given at them being almost wholly electrical.

To spend hour after hour on duty guarding against surprise in the un-

RUNNING A LINE FOR LAND MINES

certainty that the next minute may be the critical one, is trying on the nerves and tends to diminish the fighting efficiency of the men. The installation of electrical means of communication within coast fortifications has in a large measure eliminated this. It permits scouts and lookouts to be on duty at distant points, and practically does away with the possibility of unexpected attack, and hence relieves the fighting force within the fort from mental strain. Communication is by means of the telephone, telegraph, telautograph and the wireless telegraph.

A coast fortification is always equipped with a most perfect line of telephonic communication from the inland and shore sides. As it is always constructed with the primary idea of repelling an attack from the sea side, the land side is the weaker, and for this reason, being more open to attack, requires the closest guarding.

The lookout stations along the shore are likewise connected by telephone with the fortifications, and with one another as well. Thus any hostile vessel may be discovered long before getting within striking distance and its presence promptly reported. These lookout stations are so located as to cover by observation a large extent of territory for each fortification. At the boundaries of one, the next begins, thus forming a continuous chain covering the entire coast. Lighthouses and life-saving stations are utilized as lookout points, and, wherever possible, commercial telephone and telegraph lines are requisitioned for sending messages of what is observed.

The latest development in electrical communication—wireless telegraphy—makes it possible for a fort commander to immediately transmit information and receive it from fighting vessels. Thus scouting vessels can be far out at sea and give warning to the fortress of the enemy's approach long before he is sighted from the coast.

So much for what electrical communication accomplishes outside of the fort. Its uses within are of even greater importance. In order that the supreme importance of electricity in modern coast-defense operations may be better understood, it may be well to give a brief description of what constitutes a seaside fort. Wherever along the seacoast it is desired, for strategic reasons, to exclude an enemy from a harbor, sites are procured which command the water approaches. On these sites guns of various calibers are arranged, either singly or more frequently in groups of two or more. These groups are termed batteries, and the batteries, together with the necessary buildings, such as barracks, hospitals, officers' quarters, range-finding and fire-control stations, and such other buildings as may be necessary, constitute a fort. A fort thus may, and usually does, cover hundreds of acres.

No matter how far separated the various divisions of a fort may be, they are in constant and perfect touch with one another at all hours, night or day. This is made possible by telephone lines which converge at a central switchboard, just as in commercial practice. The fort commander is thus enabled from his station to direct the movements of his men in all details, though he be far removed from them. The telegraph and the telautograph, while not in as general use as the telephone, serve similar purposes. The telautograph is of especial value in range finding; reference to this will be made later on.

The submarine mine is an outcome of the Civil War, in which it was used by the Confederates, even in its then crude state, with such deadly effect that the Union cause lost no fewer than twenty-two vessels, with a dozen seriously injured. This record is far more disastrous than that of any gun fire, and as a result the submarine mine acquired a formidable reputation. There are various types of submarine mines, but the electrical mine is so vastly superior to all others for harbor defense that it alone is seriously considered. The mines are placed to seaward of the forts so that the enemy cannot get at the forts or run past, as he might do if he had a clear channel,

without encountering the mines, nor can his boats destroy the mines or cut the cables connecting them with the firing battery on shore without coming under the fire of the guns of the fort.

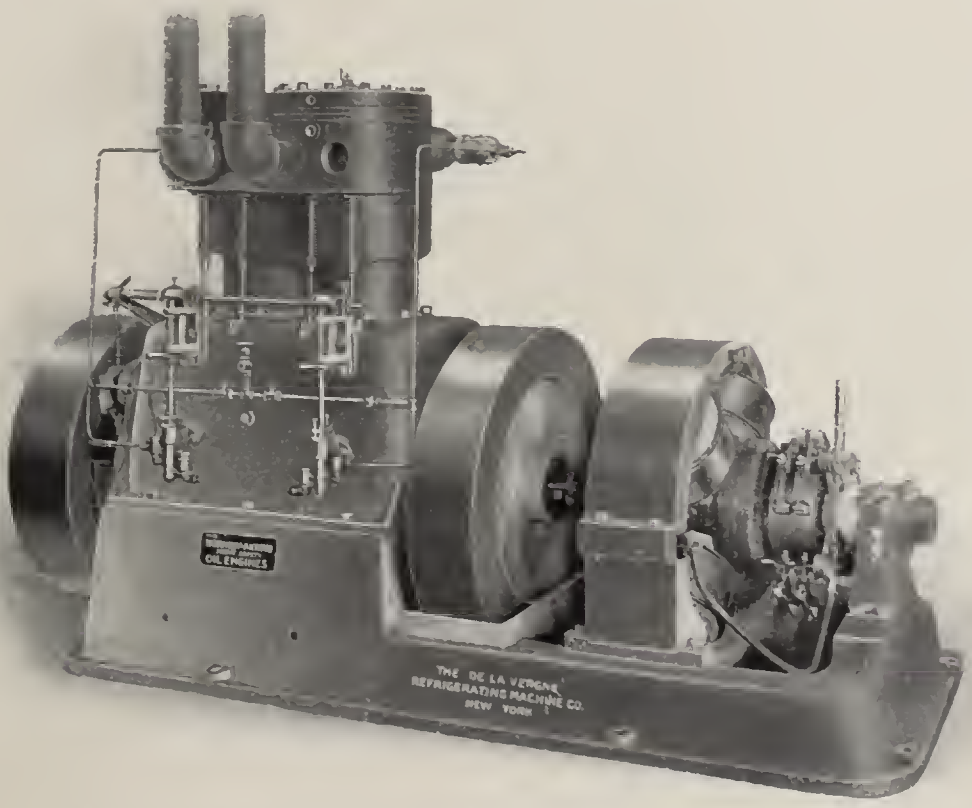
Electrically-controlled mines, while providing an efficient defense, leave the channels of traffic open to free passage during daylight and at such other times as may be secure from an enemy's approach. Their explosion is directed from an observation station on shore, or they may be fired automatically by bumping at the bottom of an enemy's ship.

In addition to the submarines, land mines are always in connection with forts. These are laid on the land side of the fortress to protect it from attack from that quarter, and are also planted along the shore front to repel the attacks of any parties which might succeed in securing a foothold on the beach.

The moral effect of land mines in protecting a fort is one of their strongest points. It has been repeatedly demonstrated that soldiers who will not hesitate to charge the strongest batteries, who stand firm in the face of terrific cavalry onslaughts, and attack double their number of infantry without the slightest trepidation, are most strongly averse to marching over ground which is known, or believed, to be mined.

There is nothing of more vital importance in a modern fort than accurate range-finding. The general plan which enables the heavy guns to be fired with such remarkable accuracy at extreme long range, often over six miles, can be best understood by consulting the illustration on page 402. For this, as well as the one on page 401, the writer is indebted to the courtesy of the "New York Herald." The one on page 402 shows two stations, *A* and *B*. The distance between them represents an imaginary line, used as a base line for the operations which follow. Given the length of this base line and the angles at which the vessel is observed, it is possible to construct a triangle, and the apex of this triangle is, of course, the exact position of the ship, the problem being a very simple one in trigonometry. Simultaneous readings are taken at both stations, and *B* transmits to *A* by means of the telautograph the angle at which the ship has been observed, the plotting board, a miniature chart of the harbor, being stationed at *A*. The location of the vessel is then transmitted to the guns either by telephone or telautograph, or both, and they are aimed as directed from station *A*.

RUNNING TEMPORARY TELEPHONE LINES



A DIRECT-CONNECTED HORNSBY-AKROYD OIL ENGINE AND GENERATOR, MADE BY THE DE LA VERGNE MACHINE CO., NEW YORK. A TYPE ADAPTED TO MILITARY SERVICE, FOR OPERATING SEARCHLIGHTS, FOR EXAMPLE, LIKE THE ONE SHOWN ON THE NEXT PAGE

A TELEPHONE CENTRAL IN A MODERN FORTRESS

The incandescent light was the first important application of electricity to coast fortifications, and it still is of the greatest value, adding immeasurably to the comfort and convenience of the garrisons. Once a plant had been installed for lighting purposes, it was seen that there was at hand a practically unlimited supply of power easy to control and always available, and it was inevitable that it be speedily utilized in many and various ways. In the barracks, cooking and heating are done by electricity, and in hot weather the quarters of officers and men are kept cool by means of electric fans. Accurate time is furnished to all parts of the fortification by electric clock circuits, and there are, in addition, electric call bells, automatic fire alarms, etc.

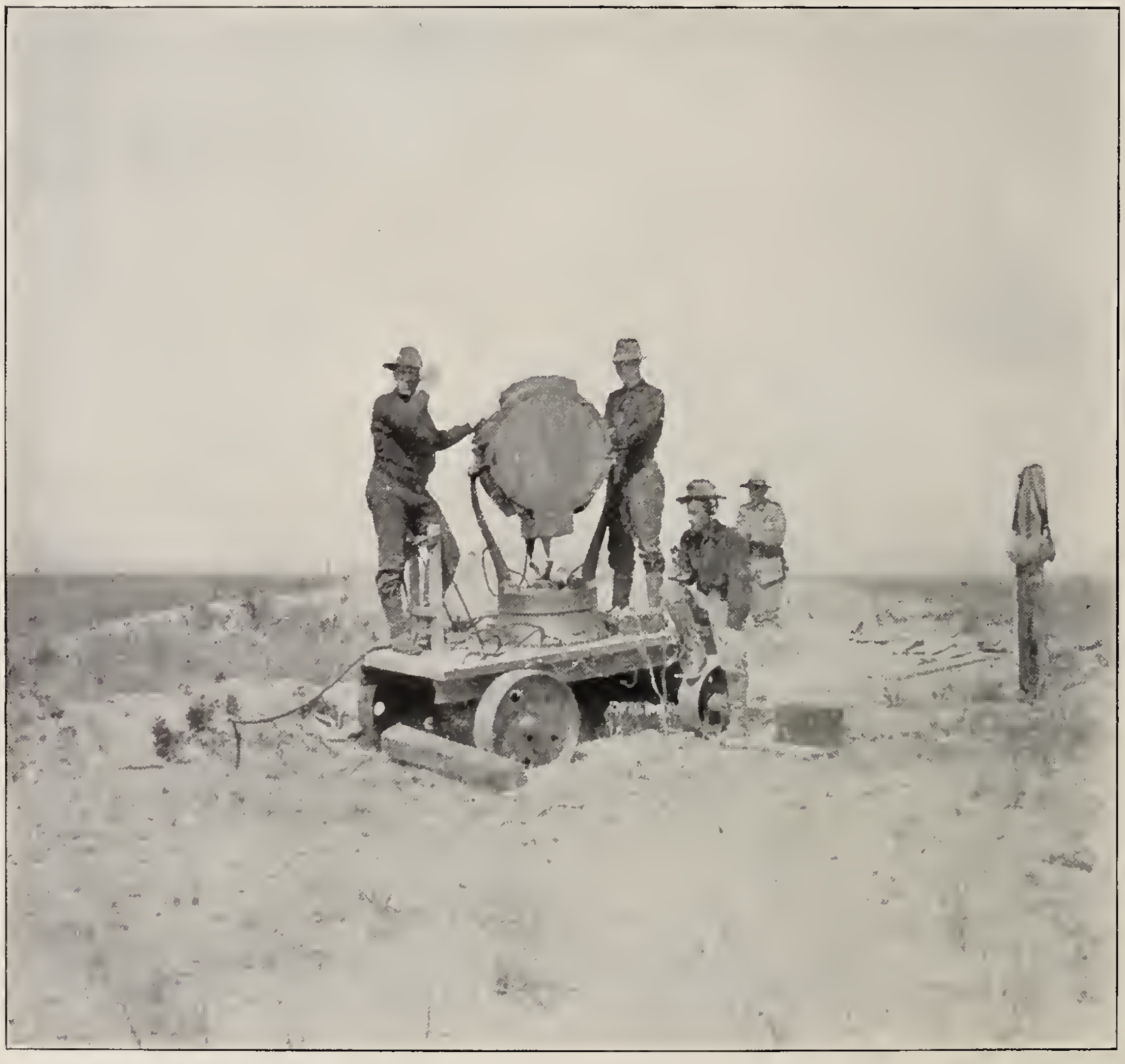
In coast fortifications, as aboard warships, the searchlight occupies a position of extreme importance. At each fort one finds the great lights mounted at various points and so situated as to sweep the approaches by sea and land and hunt out the enemy. Electric lights for signaling purposes are also in universal use in up-to-date forts.

The importance of this source of light to a fortress can be readily understood when one considers the great amount of high explosives stored underground, where artificial light is constantly being used. The incandescent lamp not only practically does away with any danger of explosion from ignition, but it has a further advantage over gas, oil lamps and candles in that it has no vitiating effect upon the air. This is a point of the greatest moment in underground operations.

The great guns of a fortification are to-day manipulated by electricity. They are raised, lowered, moved to the right or left, supplied with ammunition, sighted and fired all by means of this agent. Each large gun is controlled by means of two levers. One of these controls the motor which raises or depresses the gun, and the other controls the motor which directs the gun's horizontal movements. The ammunition hoists for bringing up charges of powder and shell also are operated easily and quickly by means of electric motors.

To the artillerist the determination of wind velocity is of supreme importance owing to the fact that it affects the flight of projectiles, and therefore means everything in the effectiveness of his fire. With the aid of the electric anemometer he is enabled to know to a nicety what the velocity of the wind is.

A seacoast fortification to-day is,



A PORTABLE MILITARY SEARCHLIGHT. THIS GENERALLY IS SUPPLIED WITH CURRENT FROM AN OIL ENGINE GENERATOR SET LIKE THE ONE SHOWN ON THE PRECEDING PAGE, MOUNTED ON A TRUCK. THE MOVEMENT OF THE LIGHT IS DIRECTED BY TELEPHONE FROM THE FIRE-CONTROL STATION

then, dominated in almost every particular by electricity. From this it is readily seen that in order to operate a fort, skilled electricians are a necessary part of the force. Indeed, the personnel should be superior to that engaged in similar work in civil life, for while the work is practically the same, the conditions under which it is carried out in the Army are, of necessity, more exacting and difficult. Unfortunately for the efficiency of the service, the electrical corps of the United States Army is entirely too small for the amount of work it is called upon to do. Earnest efforts, however, are being made to correct this condition.

It seems to the ordinary mind that the ever-increasing deadliness and scientific precision of war, which is rapidly diminishing the value of the personal equation, must make for universal peace, for the war-spirit of all time has been fostered by the hope of glory to be won through individual achievement and not through a superior knowledge of electrical science and the best methods of applying it. A certain imaginative writer has in a thrilling romance prophesied that the day was not far distant when the result of a war would hinge altogether upon the pressing of an electric button. Wild as this statement may appear, it is not as far removed from the present state of facts as existing conditions are from those of considerably less than a generation ago. Indeed, it is not at all beyond the realms of probability that war may before long be placed on a strictly and literal push-button basis.

Eras in Electrical Development

By CHARLES F. SCOTT

As chairman of the section on "Power Transmission" at the International Electrical Congress, held at St. Louis last September, Mr. Scott made the following opening remarks, hitherto unprinted, and made available for publication here by Mr. Scott's courtesy.—The Editor

THE national and international expositions held in America mark certain fairly definite eras in electrical development.

In 1876, at the Philadelphia Centennial, the telephone was announced. There was a dynamo which could supply one arc lamp. One of the features of the Exposition was a great engine of 1000 H. P.

In 1884 an Electrical Conference was held in Philadelphia. By that time electric lighting was assuming commercial significance. There were numerous stations supplying arc lights and incandescent lights. Some of these were beginning to pay dividends, marking the passage of the electrical industry from the experimental to the commercial stage. Generally speaking, however, the apparatus was crude and inefficient, there were few stationary motors; the railway motor and the alternating current had no significance.

By 1893, the year of the Columbian Exposition at Chicago, electrical matters were assuming an extended engineering and commercial development. Engine-type generators for alternating and direct current were being introduced. The street railway motor was just beginning to operate cars heavier than the ordinary street car, although the principal thoroughfare in New York City was starting a cable road. Electrical exhibits were in great prominence at the Exposition, but in looking back over a decade the most striking feature is that certain things which are now so common were there simply as exhibits.

The rotary converter was a curiosity in 1893. It began its commercial work a few years afterward, and did not become a very important element in electrical systems until four or five years later.

In a discussion upon power transmission at the Electrical Congress held that summer, an electrical engineer from California made this statement:

"I wish to say definitely that to the investor in California to-day the successful machine for long-distance transmission of power electrically exists only in the minds of the inventors and promoters, or in some beautiful advertisement."

There had been in operation for a few years a single-phase transmission of about 200 K. W. at 10,000 volts, a distance of less than 30 miles, for lighting. There were a few plants transmitting power by single-phase synchronous motors at voltages of about 3000. Although polyphase generators were in use, there was no plant transmitting polyphase current at high voltage. I remember distinctly a friend announcing to me during the congress that it had just been officially determined to use polyphase alternating current instead of direct current for the Niagara Falls Power Company. The contract for the Niagara generators was closed several months later. The Folsom-Sacramento transmission, which, I believe, may be classed as the first polyphase high-voltage system in America, was not undertaken until the following year.

In the Congress of 1904, the section which has to do with electrical power transmission deals, therefore, with a branch of engineering which has had its commercial development within the past decade, and, furthermore, the great bulk of that which has commercial value and engineering interests does not date back more than half of that time.

Approximate statistics show, that the apparatus manufactured by the leading American companies for power transmission at 10,000 volts or higher provides for the transmission of approximately 1,250,000 H. P., all by polyphase current. These striking figures indicate a quantitative or commercial development, which is, however, no more remarkable than the qualitative or engineering development.

The elementary diagram of a power transmission system with generator, raising transformers, transmission line and lowering transformers has been developed into great systems with many power houses, with networks of high-tension circuits connecting sub-stations, which in turn have distributing circuits with very exacting requirements. Substantially every element in the system, from the generator shaft to the incandescent lamp or motor pulley, has required the constant attention of the designer and engineer. Generator and transformer design, types of windings and of insulation, switchboard, switches, instruments, protective apparatus, insulators, pins and line construction, have all passed through many stages of development since the early plants were installed. Each advance in voltage, each increase in power, each increase of distance, each station or sub-station added to a system has increased former difficulties and has brought forth new ones.

Problems of transmission are not problems which can be solved in the laboratory alone. Apparatus must meet the precise conditions of operation and be judged by experience.

The transmission problem, moreover, is not one pertaining to a single plant. The conditions of climate and of service requirements are varied. That which is successful in one place and for a given kind of service may be wholly inadequate elsewhere.

The general engineering problems involved in high-tension transmission

A THOMSON-HOUSTON COTERIE OF 1893

are not those for the individual, but, broadly speaking, they are for the engineering profession. We will not succeed by isolation, but by co-operation. He who does not contribute to the general fund of experience, and he who does not profit by the experience of others, is narrow and short-sighted. Competition and rivalry should not limit and restrict progress, but should urge to better attainments. Research and experience, theory and practice must go hand in hand.

Well may we congratulate ourselves upon the progress, both quantitative and qualitative, which has been made in the past decade, but we have reached no limit, no resting place. There is every indication that the growing applications and the demands for power, the enlarging radius which high pressures make practicable, will bring more difficult and more exacting problems to the engineer, and will lead to results which in future may make our present record simply the small beginnings of what is to follow.

A great impetus was given to the polyphase system when it was adopted by the Niagara Falls Power Company and the selection of 25 cycles, a radical departure from the practice and the prevalent ideas of that time, was effective in making this frequency a recognized standard.

A few facts in connection with the power developments at Niagara Falls are significant and typical. From the first, a large portion, usually the greater part of the power developed, has been consumed by processes or industries which were not yet invented or perfected at the time that the Niagara development was undertaken. The initial installation of the Niagara Falls Power Company consisted of three generators, with a combined output of 15,000 H. P., although wheel pits were provided for two more units. The first power was delivered commercially in 1895, nine years ago. The extensions have been rapid. This company has generators aggregating over 100,000 H. P. installed. Another company is developing approximately 35,000 H. P. electrically, and plants are now under active construction for an additional output of approximately 500,000 H. P. The water rights which have been granted aggregate a total of 750,000 H. P.

Many of the electrical questions which are of particular interest at the present time are not broad and general; they are specific and in detail, and refer specifically to the particular type or form of apparatus or method of construction. In recent conferences with the engineers of three transmission systems, I found that each had a particular element in his system which was the source of most of his trouble, and yet in two of the cases the elements most liable to give rise to trouble caused little or no apprehension in either of the other plants. The difficulties in one place may not be the difficulties in other places. Hence the value of free interchange of experience and of data.

A recent writer has said that the cost of a great exposition might well be borne by the general government, as there would be value returned through the indirect impetus given to its citizens. Even from the inspiration given to a single individual, there might come results which would justify the whole cost. We have come together for interchange of information and of ideas. Fortunate will we be if, supplementing the mutual helpfulness and assistance which is sure to follow, there may be also an outlining and consideration of the problems of the future. It is well to look to the details of our present apparatus and systems. We must be awake also to the discovery of things which are radically new in materials, in design, in method, which may better solve the problems we now have and which may enable us to enter into new fields.

A Thomson-Houston Coterie of 1893

By DUGALD MACKENZIE McKILLOP

SOME old-timer of the Lynn factory of the Thomson-Houston Electric Works, with a genius for retrospect, could work up a sketch of interest relative to the changes of personnel on the various floors of the office building. A visitor to-day to the busy nests of desks in charge of Messrs. Dalzell, Green, Tirrill, Whitney, Fleming, Heath, Coates, etc., might not guess that here at the Center Street end of the third floor of that building, about eleven years ago, a calculating department was in full swing, and a well-proportioned electric library was accessory to the fact.

Because of their past and present relation to the development of the electrical industry, the men shown in the group picture on the opposite page may be of interest as a suggestive study. To the left-front is Edward B. Raymond, then in charge of apparatus testing, who, like so many prominent engineers in this section of the country, graduated from the Massachusetts Institute of Technology. On leaving Lynn, Mr. Raymond went to Chicago, but since 1895 has been in the works of the General Electric Company at Schenectady, N. Y., and most of the time has been foreman of the testing department there, and in charge of many hundreds of men. During the present year he has been advanced to the position of general superintendent of the General Electric factories at Schenectady.

Next in order is John T. Morrow, first assistant to H. F. Parshall in the room at that time, but for many years past superintendent of the electrolytic works of the Boston & Montana Consolidated Copper & Silver Mining Company at Butte, Mont.

Horace Field Parshall, educated at Lehigh and Cornell, occupies the center, and his recent photographs do not show that he has greatly changed since the days when he was the head of the calculating department at Lynn.

The next gentleman, Prof. C. P. Steinmetz, is now recognized around the world as being quite a well-equipped calculating department in himself, though at the time the photograph was taken, his worth was but dawning upon the management of that leading electric company whose commercial achievements might have been far less signal if technical Steinmetz had not been, for over a dozen years, continuously identified with it. In 1892, no patents had been issued to Prof. Steinmetz. He has subsequently been granted about 115 patents in this country, all assigned to the General Electric Company, and not a few of them patented in all the principal countries.

Readers of the October (1904) number of THE ELECTRICAL AGE will recall the racy article on "Mathematics in Engineering," written by the end-front man, to the right, Thorburn Reid, a graduate of the University of Virginia and of Stevens Institute of Technology, had considerable experience as a designing engineer before his connection with the General Electric Company. In 1896 he became associated with Mr. Parshall in England, and was engaged in designing the generators, rotary converters and transformers subsequently installed by the Central London Underground Railway. Upon his return to the United States, Mr. Reid undertook independent electrical engineering and literary work, with headquarters in New York City.

In the back row of the picture, standing in more or less disreputable array, are Messrs. Hobart, McKillop, Warner, Packard, Clulow, Bellinger,

Davis and Doane, ending with Mr. Rennerfelt at the extreme right. As in his position so in his calculations, Gustav Rennerfelt was usually right; in fact, he had discovered and marked errors in a standard book of logarithms. Like Reid, friend Rennerfelt has undertaken electrical work on his own account in New York City, and continues to take out patents from time to time.

G. Fred Packard, after an engineering experience at Schenectady, went with the Akron Electric Manufacturing Company, Akron, Ohio.

Most of the back-row men went to Schenectady, including Percy T. Clulow, who for many years held a responsible position in the data department of the General Electric Works there, which department he helped to systematize.

With singular consent, the members of the group have shaken Massachusetts dust off their feet, the whole number save one, so far as is known to the writer, being now in other parts, and two at least are domiciled abroad, though we trust not permanently.

The picture is, to some extent, a group of authors. Seven of the men represented have had one or more books issued in their names. Row No. 2 is chiefly represented in this line by Hobart's "Electric Motors; Their Theory and Construction"; and McKillop's "Annals of Megantic," and "Shorthand and Typewriting." In "Engineering" and in "Traction and Transmission," during the past few years, Mr. Hobart and Mr. Parshall have written much on the design of rotary converters and alternators, etc., which will no doubt be issued in book form.

But 'tis the front row, seated in reflective attitude, that takes the banner in the author line, and admits of no exceptions. Morrow and Reid started the book writing by their "Arithmetic of Magnetism and Electricity," an unpretentious volume brought out while yet the authors resided at Lynn. Charles Proteus Steinmetz has contributed "Theoretical Elements of Electrical Engineering," which was really an introduction to his epochal work, "The Theory and Calculation of Alternating Current Phenomena." Parshall and Hobart are the joint authors of their elaborately worked out tome on "Armature Windings," followed this year by "The Design of Electric Generators"; while E. B. Raymond has this season brought out his initial volume, "Alternating Current Engineering, Practically Treated."

But who shall enumerate the number of important technical papers that have appeared during the last half dozen years from Messrs. Steinmetz, Hobart, Reid and Parshall? Indeed, some of our electrical men have become such prolific writers of papers and books that it is a question whether spruce and poplar may not soon become as scarce as mahogany.

Photographs of a decade ago enforce upon the mind the fact that changes take place. Of the group, one was a smart dresser, another careworn-faced betimes, another apparently meek, but in reality a fiery furnace if a wrong was to be righted; while still another struck such attitudes that memory cannot let them go. What a wonderful little regiment of slide-rule and diagram specialists! To the writer, the faces of the group each tell a tale not here detailed. The unused asset of the secretary or stenographer is a more perfect knowledge of the employer and his colleagues than is the property of many. The unheralded kindnesses mingle with the petty foibles in very human-like variety, and all go to make up a man. The head of the designing department at that time was loyal to his subordinates and ready to be grateful. Some of those associated with him in technical duties in the early nineties have become co-laborers with him abroad, showing the hold he has had upon them. David P. Thomson and Henry M. Hobart are now in England.

Sir Humphrey Davy is said to have declared that his greatest discovery was when he saw the genius of young Faraday. To whom is the credit due for discerning the embryonic skill in electrical designing, literature and engineering, of the three or four men of this group whose fame is more than national, and whose industry and many-sidedness are at once the astonishment of their friends and the despair of their competitors?

Copper Production of the United States

ACCORDING to figures compiled by the United States Geological Survey, the copper production in the United States during 1903 was 698,044,517 pounds, valued at New York at $91,506,006. The figures given are for the years 1894 to 1903, inclusive, the production of 1894 and 1895 including that made from imported pyrites. The production by years follows, the values given being those at New York:

Year	Pounds	Value	Price per Pound
1894	364 866,808	$33,141,142	$0.09
1895	385,913,404	38,012,470	0.098
1896	460,061,430	49,456,603	0.107
1897	494,078,274	54.080,180	0.109
1898	526.512 987	61.865,276	0.117
1899	568,666,921	101.222,712	0.178
1900	606,117,166	98,494,039	0.162
1901	602,072,519	87,300,515	0.128
1902	659,508,644	76,568,954	0.116
1903	698,044,517	91,506,006	0.131

The Effect of the Telephone on Railroad Passenger Receipts

A PROMINENT traffic man in Buffalo has been recently quoted as saying that the growing use of the long-distance telephone for business has cost the railroads of the United States millions of dollars in passenger earnings in the last few years.

"To what extent money is diverted from us in this way can," he says, "of course, never be even approximately estimated. It is a tremendous figure, however, and is reflected to a certain extent in many of the recent annual reports. A comparatively few years ago the long-distance telephone was unknown. Its development has been marked, to the sorrow of the railroads' passenger men.

"In the volume of traffic in the United States to-day it would be impossible to get any idea of the number of people who telephone rather than travel. There must be thousands, however, for we know at least half a dozen business men in Buffalo who have given up trips that they used to take as regularly as clockwork. The telegraph never worked against passenger earnings as the telephone does."

Popular Interest in the Electric Furnace

DURING the recent electric exhibition held in the Shoreditch district of London, one of the exhibitors gave a practical demonstration of the working of an electric furnace. Such unexpected interest was taken in the demonstration by the visitors that it was necessary to build special railings around the exhibit and upon most of the nights the police were requisitioned to control the crowd. Altogether about 11,000 persons looked through the colored glasses into the furnace.

The experiments consisted of fusing quartz and refractory metals, such as iridium and chromium, but the public expressed the greatest satisfaction with pots of boiling steel or molten fire-brick.

The mileage of telephone wires in Iowa has increased from 14,043 in 1903 to 48,491 in this year.

The effect of the Exposition on the traffic of the St. Louis Transit Company is shown by the receipts for September, 1904,—$1,051,452.13 — and those for September, 1903,—$635,109.65.

Smoke Prevention

By R. S. HALE

Central-station engineers and superintendents will find a number of interesting points in Mr. Hale's discussion on smoke prevention. It was prepared a few months ago, as one of a series of reports for the Mutual Boiler Insurance Company, of Boston, and contains much that may be read with profit, even though the smoke literature of the times is already voluminous.—The Editor.

FOR nearly ten centuries laws and decrees have been issued against smoke, not including King James' "Counterblast against Tobacco," and all who have studied the subject are familiar with the conclusions reached by various "Commissions on the Abatement of Smoke." These commissions look into the subject so far as their ability and intelligence permit, make a few or in some cases numerous experiments on various smoke-consuming devices and smokeless furnaces, and then state that their study and experiments show that smoke can be prevented from practically all furnaces, and that preventing the smoke not only will not add to the cost of making steam, but will actually reduce the cost. Each time the commission closes its labors with the apparent idea that it has now solved the question.

However, in spite of the conclusions of these commissions, the users of boilers continue to permit their chimneys to smoke. If this really result in a net loss, if it be true that the boiler owner who prevents smoke from his chimney is really getting his steam at a smaller cost than the boiler owner who permits his chimney to smoke, then the state of affairs is very curious. As Lincoln said, "You can fool some of the people all the time and all the people some of the time, but you can't fool all the people all the time," and if the boiler owners who try to prevent smoke get no decrease of their net costs, while those who regard smoke-preventing devices as a bother and worry get on just as well in their business as the other, then it is very probable that these commissions which tell us of the immense saving to be made by smoke prevention may be in error at least to some extent.

I do not wish to appear as an advocate of smoky chimneys, since I prefer clean linen and a clear sky. At the same time, I should like to try to add a little to our knowledge of the subject, since it is only by accurate facts and clear thinking that we shall ever reach any improvement, and before taking up the logical development of the question I should like to tell of the result of one small branch of the investigation, viz., the value of automatic stokers, since this illustrates the errors which we may easily fall into. My first knowledge of these came from the promoters of the various types, all patented, of course, though Watt designed and built many in the century before the last, and there has been a new crop every decade since. All these promoters had authentic tests of their devices made in comparison with hand-firing that showed a saving of from 10 per cent. up to 35 per cent. or 40 per cent. and the average saving was at least 15 per cent. Fifteen per cent. saving in the coal bill will pay a tremendous return on the cost of installation of any mechanical stoker, and it seemed, therefore, that boiler owners were losing a chance to make a very good investment.

Before long, however, I began to run across instances of boiler owners who had tried stokers and discarded them on account of various troubles, such as failure to work, etc. The promoters of that stoker always assured me that the discarded machine was one of their old types and that the machine which they were now building would give no trouble. Later, however, I found cases where the boiler owner reported a decided and often large saving of coal after discarding the stokers, or an increase in the coal bill after putting them in, and in my own practice I got results from testing hand-fired boilers far better than the average stoker test and as good as the best, though of course I also found stoker tests better than some hand-fired tests. That some of the stoker companies should then admit to me (privately, of course) that they had tests on file much to the disadvantage of stokers was no surprise.

I then began to make a collection of boiler tests in which I made the rule that I would include no test that was specially selected in any way. Thus I refused any tests whatever supplied by any company interested in any patented device and omitted any published tests, even by the best authorities, if they were illustrative of any such device, since I felt sure that if the tests had not been favorable they would not have been published. I took, however, such groups as all the tests I had made myself, all the tests with which some fellow engineers were kind enough to supply me, with a statement that they were all the tests they had made, and the groups of tests made at various competitive exhibitions, the latter being mostly foreign. Even when the tests were selected in this way there was a possibility that tests unfavorable to some patented device had been suppressed; nevertheless it is better than including tests that have been specially selected to show the advantages of some particular type. The whole series is at least not unfair to the patented devices. All these tests amounted to over one hundred, and on carefully comparing them, the automatic stokers showed up less than 1 per cent. better than hand-firing. The moral is obvious.

Another illustration of the loose methods in vogue by the advocates of smoke-prevention laws occurred a couple of years ago, when some estimable Boston reformers secured the services of a famous professor from one of the smoky Western cities to testify how easy it was to reduce and prevent any emission of smoke, and he so testified before a committee of the Massachusetts Legislature. However, on looking through the reports on smoke prevention in this and corresponding Western cities, I found two of chief methods which had been successful in preventing smoke to be, first, the use of smokeless coals such as Pocahontas and New River without any change of grate, or the use of a mechanical stoker which enabled the use of a very much cheaper grade of coal. Now, Pocahontas and New River coal may be comparatively smokeless compared to Western coals, but these are the coals chiefly used in Boston and are the grade of coals against which these Boston reformers were complaining. The use of mechanical stokers permitted, in the Western city, the use of a cheaper grade of fuel and consequently resulted in a decided saving in cost of fuel; but the difference depended on the fact

that in the Western cities, "run of mine," as ordinarily used on hand-fired grates, is more expensive than slack coal, while in Boston "run of mine" is the cheapest grade, and to get slack coal would involve a higher cost of coal rather than a less cost. The methods that were available in the West were therefore absolutely unavailable in Boston, and if the whole story had been known the case of the smoke-law advocates would hardly have been as strong as it appeared to be on the surface.

We will now consider the question of smoke, not alone in the light of the experiments made by the promoters of smoke-prevention devices, but in the light of well-known facts of engineering and chemistry. First of all, we may note that anthracite coal makes practically no smoke and that coke likewise makes no smoke. Unfortunately, in all except a few districts, hard coal or coke is much more expensive than soft coal. These fortunate districts, such, for instance, as New York City, can reduce the amount of smoke to a minimum and at the same time increase the cost of their steam and of all the products of steam such as heat, light and power by but a very small amount. It has been said that New York owes its immunity from smoke to its very drastic law and not to the cheapness of hard coal, but when many plants on the other side of the river in Newark, Paterson, etc., where there is no such strict enforcement of a smoke law, burn hard coal by preference, it is clear that the use of hard coal in Manhattan is no great hardship and that it is impossible to say what would be the result if soft coal were 25 per cent. instead of 5 per cent. or so cheaper than hard coal. I venture to say that if the relative prices of coal in Manhattan should differ by the larger amount instead of by the smaller, the officials of the New York Board of Health would either have to relax very much in the enforcement of the law or else flee for their lives. In fact, when the coal strike sent up the price of hard coal in New York the Mayor suspended the smoke ordinance by proclamation.

When hard coal or coke can be used the problem is solved. If soft coal which contains hydrocarbons must be used, it is impossible to prevent the smoke nuisance entirely. Soft coal, it is true, can be burned so as to give no visible smoke at the chimney-top, and it is likewise true that an oil lamp or gas jet can be burned so as to give no apparent smoke. Nevertheless, those who use electric light know how much cleaner their walls and ceilings remain than when they used gas or oil, while the discolored ceilings over a gas jet or oil lamp show where the soot comes from. I have had instances, in my practice, of serious complaint from soot in the neighborhood of a soft-coal furnace, though even the complainants admitted that practically no visible smoke came out of the chimney.

This leads us to one very important consideration, and that is the fact that it is the actual quantity or weight of soot discharged into the air that causes trouble, while it is always the appearance of the chimney top that causes complaint. For instance, consider a furnace that gave dense black smoke for ten minutes each morning and each afternoon, or say twenty minutes in each twenty-four hours, or 1-72 of the time. If we compare such a chimney with one that gave only 1-10 as much smoke at any particular moment but gave steadily some light smoke, the latter would cause much less verbal complaint to the smoke inspectors, especially under such ordinances as are now on the statute books, but would really be giving about six times as much soot.

We may also compare a battery of boilers each with its own chimney, as against the same boilers delivering into a common chimney. If a single one of these boilers smoked very badly and the others not at all, then with individual chimneys there would be much complaint, while with a single large chimney for the battery the top would show only a light smoke which would cause but slight complaint although the amount of soot would be the same.

Another point that should be carefully considered, but that is not always considered, is the question of central power stations. The electric light and power companies are in large cities almost universally spoken of as the worst offenders against the smoke laws, but a brief consideration will show that we could afford to let them send forth almost any amount of smoke rather than put any serious burden on them. The choice whether a small factory or an office building shall put in its own plant to make its own light and power, or, on the other hand, buy electricity from the central station, is a close one, but the central station runs on a 2 pounds coal per horse-power while the isolated plant seldom gets under 6 pounds per horse-power. Hence, for the same amount of soot given forth into the atmosphere, the central station should be allowed to make three times as much smoke.

Another point that is not often considered, in fact that cannot be considered, is that the amount of soot is not proportional to the color of the smoke. A small chimney attached to a boiler that is using but a small excess of air may show a dense black smoke. Change this over to a large chimney and let a large amount of air into the flue at the base of the chimney. Then the color of the smoke at the top will be much lighter though the amount of soot may be the same as before. Supposing, for instance, that around a smoky chimney of 2-feet diameter we should build a shield 6-feet diameter, 15 feet high, open top and bottom. If the original chimney extended just above the roof, then this shield would look merely like a much larger chimney. The smoke from the small chimney inside would be so diluted with air by the time it could be seen by the neighbors that no complaint would be made, although the amount of soot would be the same as before. While such a shield has never yet been built, yet I have no doubt that much of the difference between some chimneys that cause complaint and others that do not is merely the difference in dilution by air leakage into the chimney and is not due to any difference in amount of soot discharged.

We thus see that different grades of coal from anthracite to very soft bituminous make different amounts of smoke, and that the apparent amount of smoke at the chimney top may differ without changing the real amount of soot. It is, however, also true that the same grade of coal from the same chimney may vary in the amount of soot it gives out according to various conditions of the combustion and boiler setting and furnace, and of methods of firing.

Coal, as we know, consists of carbon, hydrogen, sulphur, nitrogen, oxygen and earthy matter, and these are chemically combined into various compounds. Combination with the oxygen of the air causes these to form CO_2, CO, H_2O, SO_2, and certain nitrogenous compounds, all of which are colorless or practically colorless gases. Incomplete combustion gives soot which is composed of either pure carbon or of carbon-hydrogen compounds. Other hydrocarbons such as CH_4 and the gases are colorless. Now, naphtha, kerosene, and, in fact, all the light oils and heavy oils formed when coal is distilled have a colorless vapor; hence are not soot, but as we get above the oils and into and beyond the compounds such as paraffine and towards the compounds with a very large proportion of carbon we find the soots. The question, therefore, is, what are the conditions under which these sooty hydrocarbons are formed and burned or not burned in the furnace? The question of their formation need not bother us, for if they are not at first part of the coal, yet we

know that when compounds such as paraffine and other constituents of coal are heated they "crack," according to the chemist's term, and dissociate into the lighter colorless hydrocarbon gases and the heavier sooty residue.

These sooty hydrocarbons having been formed from the coal as it heats, the question is how to burn them. For this the requisite conditions are, of course, that oxygen shall be present, and that the temperature shall be high enough.

We cannot tell just what temperature is required because we cannot get any particular one of the many different combinations of H and C that make up soot in a pure form by itself to experiment on. We do know, however, that the flash point or ignition point of these hydrocarbons increases as the compounds become heavier, hence the higher the temperature the fewer will be the number that will not ignite and unite with such oxygen as is present, and the smaller will be the amount of soot left unburned. The question is, therefore, what temperature can we get.

The combination of the oxygen of the air with the carbon, hydrogen and sulphur of the coal gives out heat. The exact amount is quite complicated on account of the varying heats of combustion of carbon, hydrogen, etc., and on account of the phenomena of dissociation. We may, however, consider pure carbon in order to get an approximate idea. For perfect combustion, *i. e.*, with exactly the necessary amount of air to burn the carbon to CO_2, we get a temperature of about 6000 degrees C. on the basis of 8000 calories for the heat of combustion and 21 per cent. oxygen in the air and a specific heat of the products of combustion of 0.24. If more air is used, the heating of the extra air reduces the temperature, while if less air is used some of the carbon burns to CO instead of CO_2 and gives out less heat. The variations are shown in the accompanying diagram.

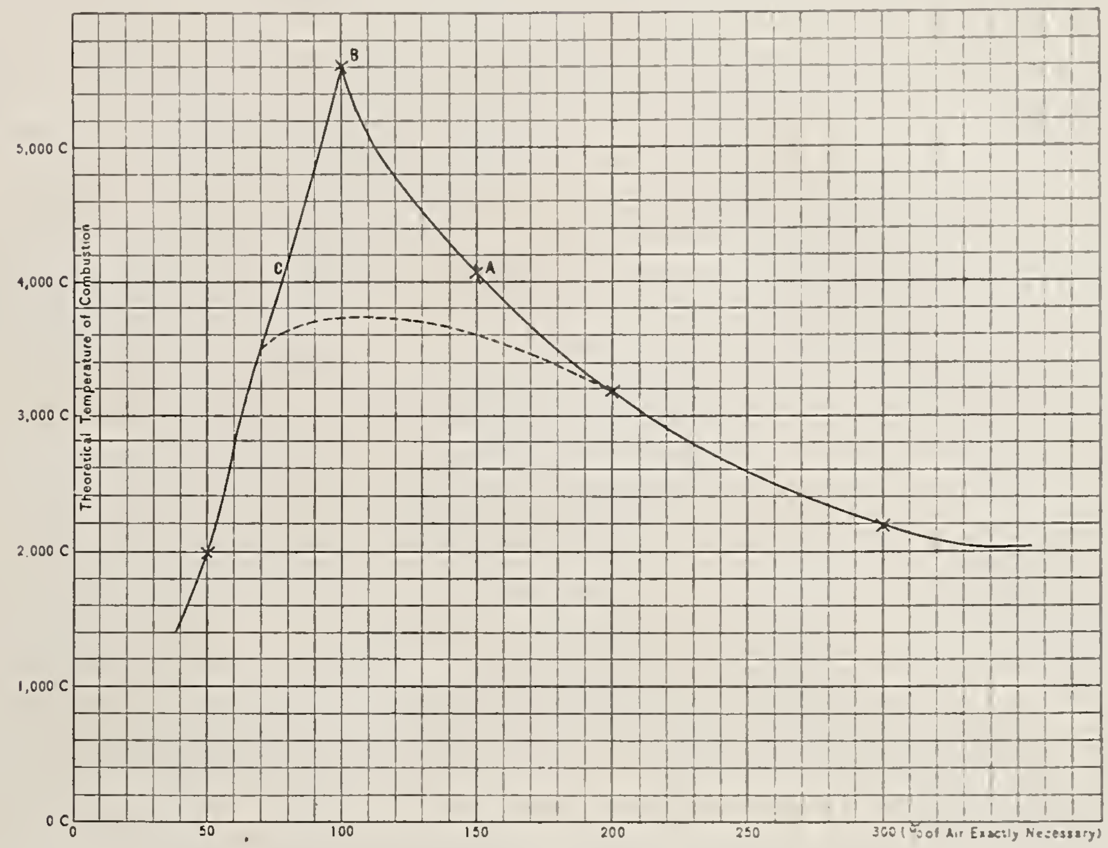
The actual temperature probably follows something like the dotted curve on account of dissociation.

It should be noted, of course, that these are the temperatures at the moment of combustion. Radiation is very rapid at the high temperatures and the temperature falls very rapidly the first fraction of a second.

Now, analyses of the flue gases usually show about 30 per cent. to 100 per cent. excess air, but a distinction should be made in that much of this air is admitted beyond the fire and that all the air does not pass through the grate, or rather, complete combustion does not take place in the fire, but some of the carbon forms CO or HC and burns with excess O_2 above the bed of coals. The flame itself above the fire shows this to be the case. In this case the fire itself probably is worked at a point somewhat on the left of the peak of the curve, say with 25 per cent. deficiency of air, and the rest of the air burning above the grate increases the later temperature of combustion to something like 2000 or more. Now, at this temperature or below, the various HC's that form soot are formed and the question of burning them to colorless gases lies in the bringing them in contact with O while still at a temperature high enough to cause them to ignite.

The question of how much soot and smoke is formed is, therefore, first, a question of the temperature of the fire which determines whether these HC compounds reach their ignition temperature; and second, the question of air supply which determines whether there shall be enough O at the right time; and, third, the question of mixture of the O with the HC, since, of course, extra O does no good unless it is brought in contact with the HC at the proper moment, but in fact does very serious harm.

If, while the temperature is high enough, enough oxygen is supplied and properly mixed with the hydrocarbon, the maximum amount of the hydrocarbons will be burned and the minimum amount of soot formed. Any failure to give the highest possible temperature, to give sufficient oxygen or to mix the hydrocarbons with the oxygen at this temperature will increase the soot. The harm done by extra oxygen may here be briefly referred to. If extra oxygen be supplied that does not burn, then the temperature of combustion and of the gases above the fire is seriously reduced, as is shown by the curve in the diagram on this page. This immediately reduces the rate of transfer of heat from the gases to the heating surface, while, at the same time, the length of time that any particular pound of gas remains in contact with the heating surface is also reduced by the same serious amount, since a greater quantity of gas passes over the heating surface in the same time. The less time offered for transfer of heat and the lessened rate of transfer of heat both operate to reduce the amount of heat taken up by the heating surface, so that the quantity of heat lost by the heat of the waste gases in the chimney is greatly increased. As this already is the most serious loss (amounting usually to two-thirds of the total waste of heat in making steam), any increase in its amount is a very serious matter.



THEORETICAL TEMPERATURES OF COMBUSTION WITH VARYING QUANTITIES OF AIR. THE ACTUAL TEMPERATURES ARE LOWER, DEPENDING ON DISSOCIATION AND RADIATION

Returning now to the three factors governing the emission of smoke and soot, viz., temperature of ignition, supply of air, and mixture of air with the gases, some of the conditions work out very simply to practical results. In the first case it is obvious that the fire itself should be worked on the left-hand side of the peak of the curve on this page, *i. e.*, that there must be incomplete combustion just in and just over the fire in order to get the best results. If the fire is worked on the

right-hand side of the curve, say at A, with 50 per cent. excess air, then the temperature falls at once by radiation of heat to the heating surface and no time is given for the consumption of the hydrocarbons. If, however, the fire is worked exactly at the peak, say at point B, the dissociation reduces the temperature to, say, 2000 degrees, and the reverse of dissociation maintains this temperature for a short time as the gases cool, giving longer time for combustion of those hydrocarbons that need the high temperatures. Further, if the fire is worked at the point C, just at the beginning of dissociation or thereabouts, and the air is supplied gradually, the temperature will be maintained over a still longer period.

This explains at once the effect of air admission over the fire and its advantages which have been shown in tests since the days of Williams in the first half of the last century, or even earlier.

The great danger of such air admission if the fire is not worked properly is also apparent. If the fire should be worked at the point A of the curve instead of C and air should then be admitted over the fire in addition, the loss would be very serious indeed and there would be no corresponding gain except the apparent diminution of the smoke issuing from the chimney due to its dilution.

The question of mixture of the air with the hydrocarbons is seen to be very important when we figure the time allowed. A rate of combustion of 20 pounds coal per square foot hour is not unusual. This makes roughly about 20 pounds gas per pound coal, or 400 pounds gas. At ordinary temperatures, say 60 degrees F. or 500 degrees absolute, this makes about 13 cubic feet per pound, while at combustion temperature of, say, 2000 degrees C., this is about 100 feet per pound of gas, making a total of 40,000 cubic feet per square foot per hour, or 11 feet per second. In some forms of water-tube boiler the gases have but 3 feet or so of travel before they enter the tube nest, or the time of mixture and ignition is but 1-3 of a second. By providing a large combustion chamber, as may be done, for instance, in a horizontal tubular boiler, this length of time may easily be increased four times.

It is impossible to do more than estimate this average time. In a horizontal tubular boiler, for instance, some of the gases undoubtedly travel the whole length of the boiler. Others travel only the vertical distance from the grates to the shell, but if they then deflect they may mix with other gases hot enough to keep up the temperature to the proper point and have a longer time for ignition. It is only possible to make a rough comparison of different types of boiler and different types of setting, but we have an interesting case in some boilers, designed by Mr. E. D. Leavitt, which are under the charge of our company. There are two batteries side by side, the old battery set 2 feet above the grates, the new battery 4 feet. Otherwise, the boilers are practically duplicates, but the lessened smoke emission from the latter is very marked and is probably due to the larger combustion chamber. Of course, it must be remembered that this difference in setting increases the headroom required, increases the cost of setting and increases the annual repairs to the setting.

The advantages of a brick combustion chamber or brick arch in maintaining the temperature are very obvious. On the other hand, such construction, especially the arch construction, needs frequent repairs, and some designs of brick combustion chambers, such as checkerwork, check the draft and reduce the capacity and need frequent cleaning from ashes.

Another method of maintaining the temperature is the down-draft principle, whether in the Hawley type or in the underfed stoker. These supply the coal where the fire is coolest instead of where the fire is hottest, and force the gases as distilled from coal when first heated to pass through the hot fire. The effect obviously must be good.

The cost of these is high, both for installation and repairs, and it must be remembered that the apparent cost of repairs is not the only cost. Repairs involve laying off the boiler, and the fixed charges such as interest and taxes all go on whether the boiler is used or not; in addition to this, the use of any apparatus subject to repairs involves keeping extra plant ready in case of accident that may happen unexpectedly to a minor part and cause the laying off of the boiler. Any such apparatus further requires more supervision on the part of the superintendent or manager. A much larger proportion of the time of the superintendent will be found to be devoted to the power plant when any special apparatus is employed.

We will return to special devices for smoke prevention later, but will now consider the methods of firing.

Careful firing of only a small quantity at a time is an effective means of reducing smoke. If a large quantity of coal is fired at one time the hydrocarbons distil first and require an almost impossible amount of care to prevent smoke. As soon, however, as the coal is coked the smoke stops and no further attention is needed until further firing is required, when the same difficulty again appears. On the other hand, if one or two shovelfuls of coal are placed on a hot fire the temperature is usually enough to burn these hydrocarbons as they are formed, and if the firing is kept up steadily a little at a time, much less smoke is formed than if a larger quantity of coal is fired at once. It must be remembered, however, that this means very much harder work. It is nearly twice the work for a fireman to fire 15 shovelfuls of coal at 2-minute intervals than to fire 17 shovelfuls at once and then rest half an hour. The actual work is much harder so that more wages would have to be paid, and in addition there must be some sort of supervision to see that the method of firing is carried out. It would be impossible to get any man, even for double wages, who was both willing to do the extra work required by the one-shovelful method and trustworthy enough to have no supervision at all. Supervision in a large plant might not be very expensive but in a small plant would be a serious tax, since a small fraction of the superintendent's time would cost as much as the whole wages of the fireman.

Mechanical stokers which feed the coal in a little at a time are of course nearly equivalent to the one-shovelful method. In large plants the saving in labor by the use of a mechanical stoker is often sufficient to pay the fixed charges and maintenance, and in such cases they may even reduce the total costs. In small plants there is no saving in labor, and the high fixed charges and maintenance make them an expensive luxury, even if they should be found to reduce the coal bill, and, as I have pointed out in the beginning of this article, the trend of the evidence of all except the stoker promoters is opposed to the idea that stokers save any coal. Further, while automatic stokers reduce the smoke they do not get rid of it entirely.

Steam jets which blow a mixture of steam and air above the fire undoubtedly reduce smoke, the action being probably just the same as ordinary air admission. They are effective because they are more fully under control than ordinary methods of air admission above the fire. They result, on the average, in a distinct loss of economy.

The considerations of the three factors of temperature, sufficient air, and sufficient time for mixture shows us at once why boilers working easily smoke less than when pushed. If a boiler is worked at half its rating the gases have twice the time to mix with the air supply above the fire before they strike the cooling surfaces and, in

addition, the same amount of soot per pound of coal makes but half the bad appearance at the chimney top.

From the above discussion it is seen that it will be perfectly possible to reduce the smoke nuisance either partially or absolutely. To prevent it absolutely requires only a law forbidding smoke emission, and this will practically force the use of hard coal or coke. In certain districts, such as New York City, this involves very slight increase of cost to the boiler owner. In other districts it would mean a very great increase of cost.

Short of the use of hard coal or coke, smoke cannot be entirely prevented. In a manufacturing district dependent upon the production of cheap power for its very existence, it is probably unwise to put any limit on the production of smoke. Any such restriction will increase the cost of manufacturing, and the reformers, while they may reduce the smoke nuisance, will find they have checked the development of the very basis of existence of the town.

In districts partly residential, partly manufacturing, it is a question of judgment. Some restriction on smoke production is probably wise. Complete restriction is undoubtedly unwise unless it is practicable to force the use of hard coal.

The question of the form of the law is a very difficult one. As has been shown, the amount of soot is the governing factor in causing annoyance, but this cannot be determined except by tests of the gases, collecting and weighing in a chemist's balance, and this is commercially impossible. In fact, it is found impracticable even in many expert boiler tests. Hence, the appearance of the chimney mouth must be used, though that is known to be subject to error in showing the real harm done by the soot. The average appearance should be at least a factor, since a chimney that gives dense smoke for a few minutes a day, but is smokeless the rest of the time, is far less injurious than a chimney that continually gives forth light smoke. Absolute prohibition of even dense smoke is impracticable, since it would be impossible to get a fireman so careful as not to make such smoke at times when firing for a sudden call for steam or when cleaning fires.

The following is suggested:—The emission of dense smoke for more then 15 minutes during the 24 hours to be forbidden.

Smoke to be divided into dense, medium, light and none, counting, say, 3 for dense smoke, 2 for medium, 1 for light, and 0 for none, and an excess of over an average of $1\frac{1}{2}$ during any 10 hours to be forbidden. In cities using much soft coal of smoky varieties these limits might have to be increased, while in cities such as New York, where hard coal can be easily and cheaply obtained, they might be diminished.

The important question, however, lies in the administration of the law. It is absolutely impossible to draw up a smoke law that will operate itself or that can be trusted to unskilled hands. The question of smoke is, in fact, like our police laws. We have laws against drunkenness, but if every man who got drunk in his home or club or even on the street was arrested and fined, what a howl there would be! We have laws against betting and gambling, but if every man who bet a cigar or every church sociable that had a grab bag were hauled into court, what would people say? The question of the enforcement of these laws is left to the discretion of the police, and the question of smoke abatement should be treated in much the same way. The law itself may be reasonably rigid; its enforcement must be reasonably lax. There should be no need for a separate smoke commission, since the multiplication of departments with special offices, clerks and other paraphernalia is unwise. The Board of Health, the Board of Public Works, the Street Department, or the Police Department itself are all suitable bodies to have charge of the enforcement of the smoke laws if the members are wise and intelligent.

There is one principle that has never, to my knowledge, been included in a law that is, I think, workable and suitable, and that is the placing of a tax on the use of soft coal. As we have seen, there is no possible way of getting rid of all the smoke and soot if soft coal is used at all, even if the chimney should appear absolutely smokeless. It would not be reasonable to forbid the use of soft coal absolutely except in very special cases nor to put a prohibitive tax on its use, but it would seem to be reasonable to say to coal users:—"If you insist on using soft coal you must contribute to the public funds some, though not all, of the profit that you make by its use."

In cities, for instance, where, after allowing for the different quantities of steam produced per ton of coal, soft coal is $1 per ton cheaper than hard, it would be entirely reasonable to collect a tax of 25 cents per ton on semi-bituminous coal containing, say, between 7 per cent. and 17 per cent. of volatile hydrocarbons to total combustible, 50 cents per ton on coal containing between 17 per cent. and 30 per cent., and 75 cents per ton on all coal containing over 30 per cent., or if these seemed too onerous the tax could be made a graded one, 10, 20 and 30 cents. Such a tax could be easily collected when the coal entered the city either by rail or boat, with appropriate provisions for coal that was merely in transit through the city. It would require but little analysis, as most coal would fall at once into one of the grades by mutual consent without any tests, and even when tests were required for the tax and were not required by the purchaser of the coal to make sure he was getting what he was paying for, the expense would be very light.

While such a tax would, I think, be highly successful, and while the average smoke emitted over a long period should be just as much considered as the number of minutes during which dense smoke is emitted, instead of only considering the latter, as is now the case with most smoke ordinances, yet it is on the personnel of the commission that has the enforcement of the law rather than on the law itself that successful results will depend. If the commission should devote itself to the encouragement of proper design of boilers and setting and to the installation of suitable capacity, then, if it does this wisely, it can do good without causing friction among coal users or greatly increasing their costs. Without such intelligent work, however, nothing can be accomplished in the line. For instance, in Boston there is a rule that no new boiler will be allowed, unless its owner agrees to burn hard coal or to put in a smoke preventer. This is a good rule, but in its enforcement the officials care nothing about the form of smoke preventer and take no interest in the design of the boiler or of the setting, and as a result the provision is of but slight practical effect in smoke prevention, but does increase the cost to the boiler user.

The methods to be adopted by those who have enforcement of the laws cannot be laid down exactly, as they will require the exercise of great tact and discretion so as to obtain the best results with the least increase of cost to the users of coal. Some remarks, however, may prove of value.

In the first case, all new installations should be submitted to the commission or inspectors and influence should be used to get ample capacity, i. e., ample grate surface and ample heating surface, as these are very important factors in reducing smoke. Influence should also be used towards providing an ample combustion chamber. Unfortunately, this latter requirement will lead to the discouragement of the use of certain patented forms of boilers, but this is unavoidable. The use of

hard coal should be encouraged as far as possible.

The commission, still exercising its powers with tact and discretion, would, of course, discriminate between plants in the purely residential parts of a city and plants in the business or manufacturing portions, just as the board of police or license commissioners exercise a wise (or what should be a wise) discretion between granting liquor licenses in different portions of a city.

In dealing with existing plants the same principles would apply. A boiler user has no right to inflict soot and smoke on the city merely because he would like to get double the power out of his present boiler plant, unless he had the right originally when he put in his plant.

I think, therefore, that we may fairly conclude that the smoke and soot question is like the liquor evil, the social evil, and the gambling evil. We can seldom or never get rid of it entirely, but by a wise discretion we can diminish its evils.

This wise discretion lies in the hands of those who enforce the law, and those who desire the evils diminished should devote their attention to seeing that the enforcement is in the hands of wise, able, and discreet men. Tampering with and amending the smoke laws will have no more effect than the various tinkerings of the liquor laws have had in the past. In any districts where it is wise to put any restriction at all on the production of steam, almost any kind of a law may be put on the books provided its enforcement is in the hands of an able, honest and intelligent commission.

An Automobile School

THE educational department of the West Side Young Men's Christian Association in New York, in co-operation with the Automobile Club of America, and with many of the largest automobile companies in the country, has undertaken to organize and conduct practical courses in automobile engineering.

Three courses are provided, the aim of which is to train and supply competent operators and chauffeurs and to give owners and prospective owners a sufficient knowledge of the theory and practice of automobiles and automobiling to enable them to meet the emergencies that constantly arise in connection, not only with machines, but with chauffeurs.

The first course consists of lectures on steam, gasoline and electric machines. Supplementary lectures will be given from time to time on such topics as the general care of tires, the use and abuse of gasoline, laws regarding the use of the roads by automobilists, and the like.

The second course will consist of draughting and designing, and the third course of operative work.

The Production of Aluminium in the United States

THE production of aluminium in the United States during 1903, according to Joseph Struthers in the United States Geological Survey report, is estimated at 7,500,000 pounds, as compared with 7,300,000 pounds in 1902, and 7,150,000 pounds in 1901.

It has not been possible to obtain exact statistics of the production of aluminium for the reason that the sole producer in the United States, the Pittsburg Reduction Company, declines to state, even approximately, its output. But judging from the extension of the uses of the metal and its alloys for such constructional and decorative work as requires lightness and no great strength, together with the increased quantity of aluminium, in the form of wires and bars, used to replace copper for conducting the electric current, it is fair to assume that the production of the light metal in the United States is steadily on the increase.

This assumption is strengthened by the fact that the quantity of bauxite (the crude mineral from which aluminium is extracted) consumed during the last few years has been successively larger and larger, the consumption being based on the domestic production plus the quantity imported.

Despite the increasing demand for aluminium, due to the extension of its uses both as metal and as alloys, the price per pound has continued practically stationary throughout the years 1901, 1902 and 1903. The prices in the United States during the years mentioned are given in detail in the following table:—

PRICES PER POUND OF ALUMINIUM AND ITS ALLOYS DURING 1901, 1902 AND 1903

	Small Lots	100-lb. Lots	1000-lb. Lots	2000-lb. Lots
No. 1 (aluminium, 99.75 per cent)	$0.37	$0.34	$0.34	$0.33
No. 2 (aluminium, 90 per cent)	.34	.33	.32	.31
Nickel-aluminium casting metal (10 per cent nickel)	.39	.35	.34	.33
Special casting alloy (80 per cent aluminium)	.35	.30	.29	.27

The price of ingot aluminium during 1903 was adjusted by an agreement between all of the aluminium producers in the world.

In November, 1894, 744 cast-welded joints were made in the tracks of the St. Louis Transit Company, and today the track is still in use, only three of the joints having broken.

Electricity in Fire Fighting

ACCORDING to "The Electrical Engineer," of London, the city of Manchester has recently introduced in its fire department a self-propelling engine fitted with a dynamo, air-pump and telephone system. This arrangement is intended primarily to assist the fireman in rescuing persons overcome by smoke, and to fight the flames in situations where the absence of such apparatus would render his position untenable.

The fireman's headgear comprises a hood, to which is atached an air-pipe, telephone instrument and an incandescent lamp. Thus provided, the fire guardians can operate in situations where the absence of such an outfit would mean prompt asphyxiation. The fireman obtains a supply of pure air, enabling him to breathe in the foulest atmosphere, the incandescent lamp provides illumination, and the telephone establishes communication with the chief of the party. A great feature of this innovation is that, like most ingenious devices, it is comparatively simple.

The additional equipment on the fire engine is not large, consisting of a small dynamo and the telephone apparatus. The dynamo, which supplies current for eight 32-candle-power lamps, is driven, like the air-pump, from the fly-wheel of the steam pump.

Wireless Telegraphic Communication with a Balloon

ON November 11, at St. Louis, the experiment was tried of communicating with a balloon in flight by means of wireless telegraphy. Messages were successfully sent and received at altitudes varying from 800 to 1,500 feet. The apparatus was carried in a basket suspended close to the balloon basket, and two coils of copper wire, each 150 feet long, were used, one being fastened to the top and coiled around the ballon until it reached the tuner and the responder. The other coil was also connected to these instruments, but was swung beneath the car.

A plea of guilty was recently made by a man over the telephone to a justice at the other end of the wire. The justice found the man guilty and assessed a fine which the guilty one promised to pay.

Electric Traction on Steam Railways

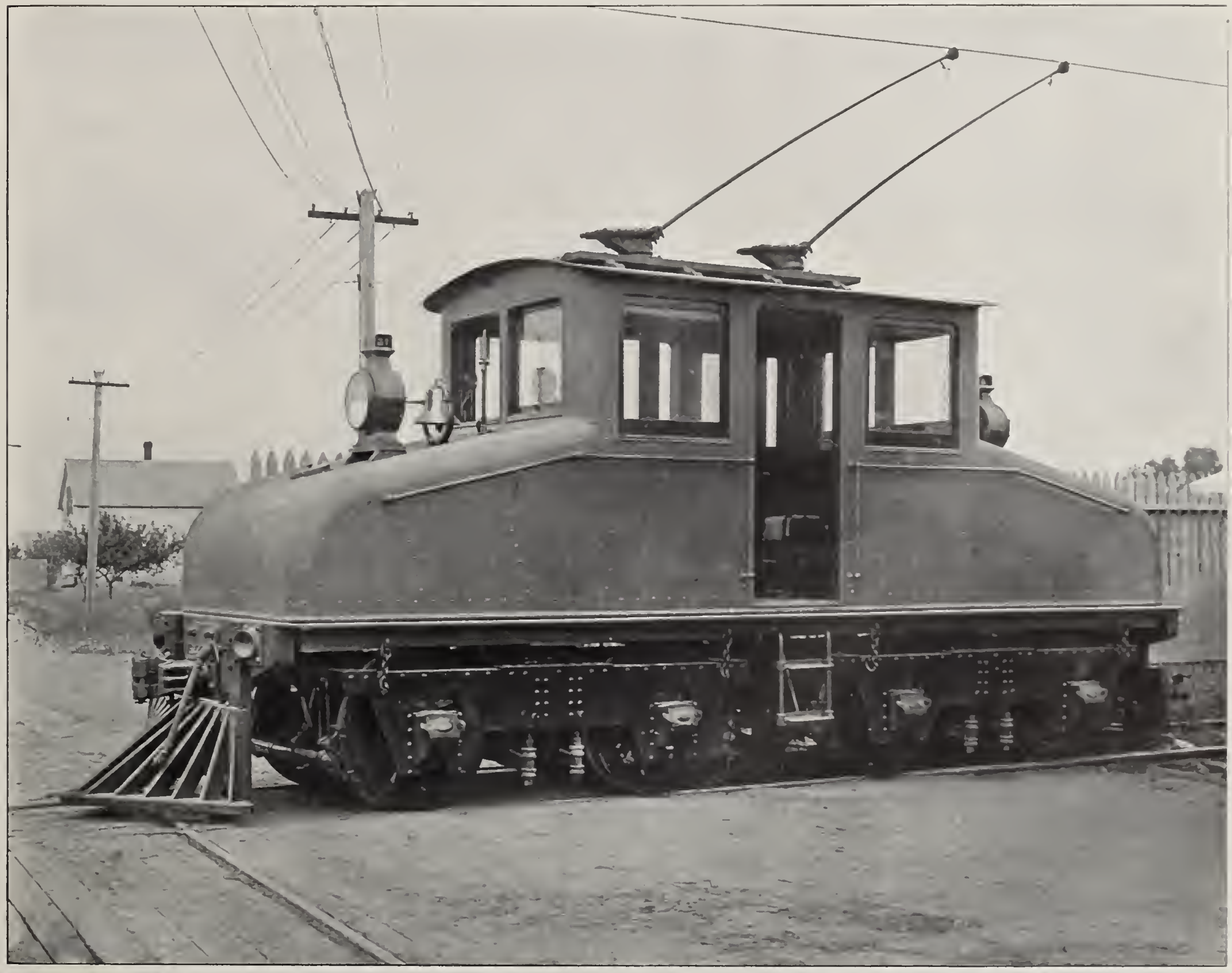
By ALTON D. ADAMS

Mr. Adams's analysis of the electric traction problem for steam railways is particularly timely just now. Electrification of such railways has been going on for several years, more or less extensively, in different parts of the world, but, naturally enough, in a tentative manner only. Traffic managers and engineers were feeling their way slowly. With the experience thus gathered, however, more elaborate electric conversion plans have cropped up in many different places, the most important of them all thus far being those of the New York Central Railroad Company, whose first large electric locomotive,—one of a series of between thirty and fifty,—was recently completed by the General Electric Company and tested near Schenectady, as told elsewhere in this issue. The several illustrations accompanying Mr. Adams's article tell in their own way of electric locomotive enterprise in the immediate past and are correspondingly interesting, even though they do not form a complete chain in the history of the development.—THE EDITOR.

ELECTRIFICATION of steam railways is being brought about by the growth of traffic and the progress of invention. For a traffic so heavy that it must, or may with advantage, be distributed to a large number of trains, operated at short intervals of time and distance, the system of electric traction developed on suburban and interurban railways during the past decade is well suited. With a traffic so light that only a few trains at long intervals of time and distance are required, a system of electric traction radically different from that in most common use is necessary.

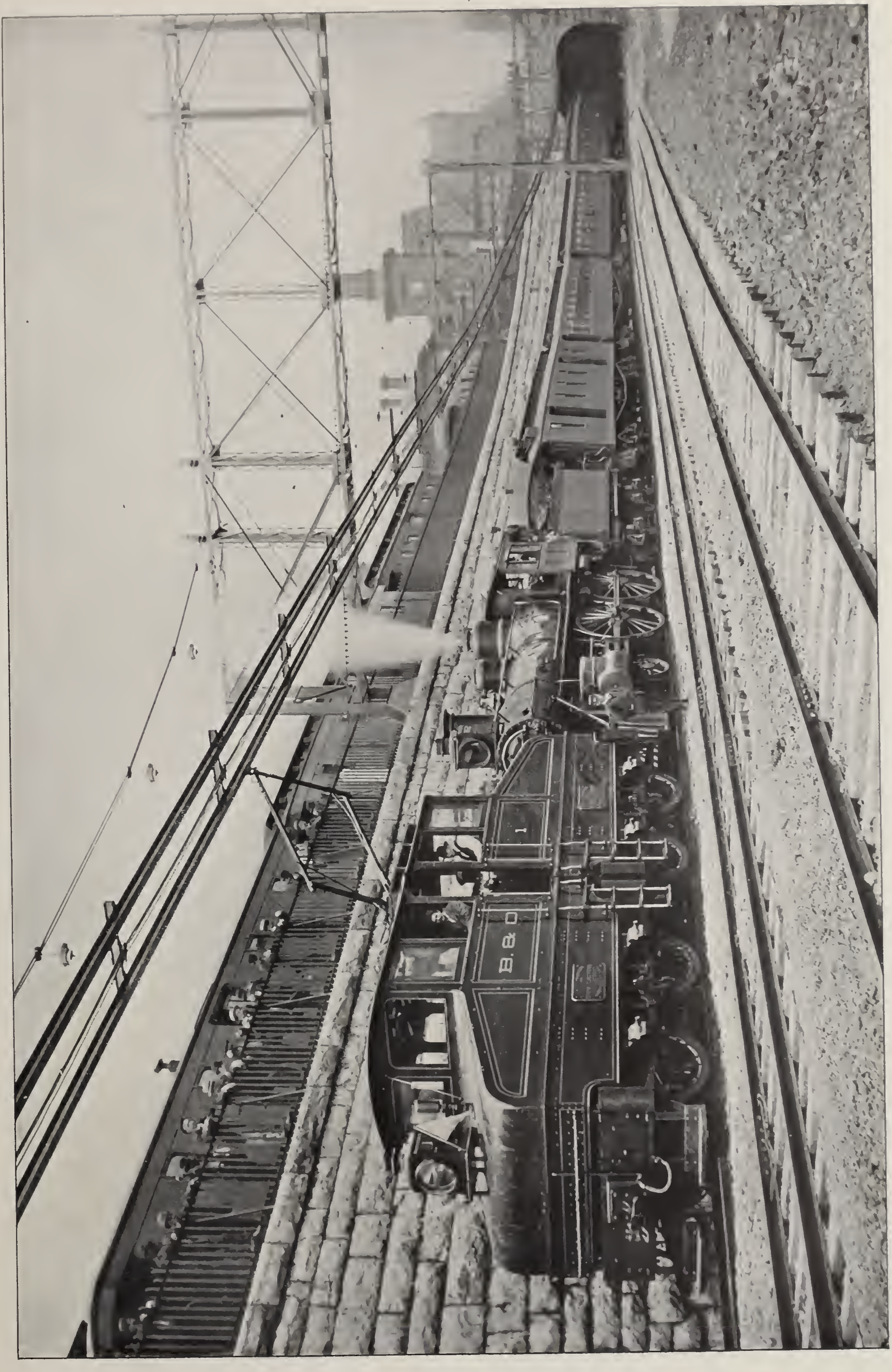
Thus it is that while inventors are in search of a system of electric traction suited to concentrated traffic, the growth of traffic from the concentrated to the distributed form is making such a system unnecessary on many parts of steam railways.

Electrification of the New York



ONE OF THE FIRST ELECTRIC LOCOMOTIVES BUILT (1894) FOR STEAM RAILWAY SERVICE. IT WEIGHS 35 TONS AND HAS FOUR 125-H. P. MOTORS. NOW IN FREIGHT SERVICE AT THE PONEMAH MILLS AT TAFTVILLE, CONN.

ONE OF THE TWO 36-TON ELECTRIC LOCOMOTIVES HANDLING PASSENGER AND FREIGHT TRAINS BETWEEN BUFFALO AND LOCKPORT. NORMAL RATING, 300 H. P. BUILT BY THE GENERAL ELECTRIC CO., SCHENECTADY, N. Y. THERE ARE FOUR MOTORS, GROUPED IN TWO PAIRS



ONE OF THE EARLIER BALTIMORE & OHIO 96-TON ELECTRIC LOCOMOTIVES COUPLED ON TO THE "ROYAL BLUE" TRAIN WITH ITS STEAM LOCOMOTIVE. THESE LOCOMOTIVES, THREE IN NUMBER, ARE IN SERVICE IN THE BALTIMORE BELT LINE TUNNEL AND HAVE FOUR MOTORS OF 300 H. P. EACH. BUILT BY THE GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

TWO DOUBLE-UNIT ELECTRIC LOCOMOTIVES, EACH UNIT WEIGHING 80 TONS, HAVE MORE RECENTLY BEEN SUPPLIED TO THE BALTIMORE & OHIO RAILROAD BY THE GENERAL ELECTRIC CO. THE ILLUSTRATION REPRESENTS THE COMPLETE 160-TON LOCOMOTIVE

ends of the Central, Pennsylvania and Lackawanna Railroads is an illustration of this fact. On the New York Central Railroad electric traction is to run out about 35 miles to Croton on the main line, and 24 miles to White Plains on the Harlem division. Besides all the through and local trains of the New York Central on these divisions, there are also all of the New York, New Haven & Hartford trains that enter the city, so that the total number of trains passing in and out of the Grand Central Station is said to be fully 350 on each business day of the year. Clearly this is a case of distributed traffic that may be readily handled by the system of electric traction successfully applied on suburban and interurban lines.

Of course, some changes are necessary in the design of apparatus to handle trains instead of single cars, and to concentrate the power of each train on one or more electric locomotives. These changes in details, though vitally important, do not affect the general character of the system which the distributed nature of the traffic makes possible.

This system, as adopted by the New York Central, is the well-known combination of high-voltage, three-phase generators, transmission lines to numerous sub-stations along the railway line, and transformers and converters at these sub-stations to deliver direct current at about 650 volts to distribution feeders, for the supply of motors on the electric locomotives.

It is understood that the alternators are to operate at 25 cycles per second and 11,000 volts, though, of course, either of these figures might be changed without altering the character of the system. Current will go to the electric locomotives by way of a third rail on some parts of the railway, and on overhead trolley wire on others. Each locomotive, as told in another article in this issue, is equipped with four motors rated individually at 550 horse-power and 600 volts, giving a normal capacity of 2200 horse-power, and is expected to haul a 500-ton train at 60 miles an hour.

In this system it is essential that each sub-station be kept at work a large part of the time, or else the investment in distributing apparatus grows so large that the advantages of electric traction are more than offset. And yet, the radius of efficient supply from each sub-station at 650 volts is hardly more than 5 miles.

These two conditions can evidently be met only on lines where the traffic is so heavy that it can be distributed among a large number of trains, run at rather short intervals of time and space. But this is just the condition that already exists on long suburban and interurban sections of many steam railways. No doubt it would be difficult to say at just what point the distribution of traffic and the number and frequency of trains became sufficient to warrant the substitution of electric traction with direct current at 600 volts for steam locomotives.

It is an open question, however, whether the amount and distribution of traffic on the entire length of some trunk line railways has not already reached a stage where electric traction at 600 volts may, with advantage, replace steam locomotives. Take as an example the New York Central Railroad between Syracuse and Rochester, a distance of 80 miles,—which has 44 passenger trains passing over it on every week day, besides a number of freight trains that cannot be stated. Between Syracuse, Albany and New York the number of trains is greater than that just named, and the same is true for that section of the road between Rochester and Buffalo, if the suburban trains about the latter city are included. Is there not much to show that electric traction with direct current at 600 volts can displace steam with advantage, on a railway where the section with the lightest traffic has between two and four trains per hour, on an average, throughout each 24 hours?

However this question may be answered, the conviction is rapidly gaining ground that this well-developed system of electric traction will show an economy over steam for the service within what may be termed the suburban radius of great cities. It is this service that is to be handled by the new equipment of the New York Central, and the signs of the times point to a demand on the part of the public, as well as to a movement by railway managers, for electric traction on the suburban sections of other steam roads that enter great cities.

Without regard to the probable

saving in expenses of operation, the greater cleanliness, comfort and safety of electric traction are weighty arguments in its favor on the suburban sections of steam roads. In the application of direct-current distribution at about 600 volts to the suburban sections of steam roads there are many matters of detail, such as the form, number and capacity of motors per locomotive or train, to be worked out, and on such points the experience gained with the new equipment of the New York Central will be of great value.

But these matters are only details that are to be worked out by well known engineering formulas. The essential characteristics of the system have already been thoroughly developed on the suburban, interurban and elevated railways of cities.

IN THE CAB OF ONE OF THE 160-TON BALTIMORE & OHIO LOCOMOTIVES

As far as the suburban sections of steam railways are concerned, a system of electric traction well suited to the requirements is ready for adoption as fast as railway managers and public opinion are educated up to its advantages.

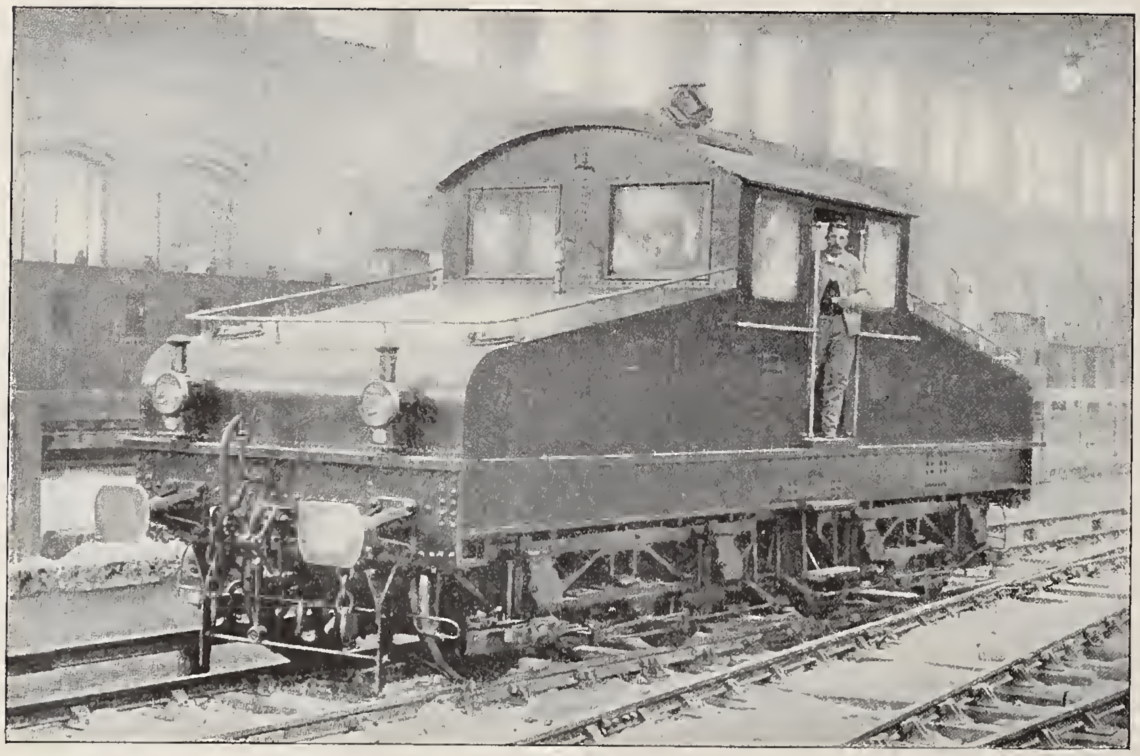
But what of typical long-distance traffic on steam railways, where the transportation service is concentrated in two to a dozen trains daily? How is electric traction to be applied on steam roads between Buffalo and Chicago, Omaha and St. Paul, or St. Louis and Denver? On these lines, with comparatively few trains, far apart in time and distance, the investment in the system of electric traction that depends on the distribution of current at 600 volts from sub-stations would be prohibitive. Must the electrification of these roads be deferred until Kansas grows to be as populous as Massachusetts, and the traffic between Chicago and Denver becomes as heavy as that between New York City and Buffalo?

These are the questions that invention must answer, or, it should be said, has already answered. That the concentrated loads of many steam roads would require too great investments, in a system of electric traction where current was distributed from sub-stations at 600 volts, is capable of demonstration.

Consider, for example, a railway 100 miles long, on which a car or cars requiring 2000 horse-power must be kept in motion. If twenty cars, taking a maximum of 100 horse power each, may be employed for the traffic, the electrical conductors and distributing apparatus will never be required to deliver more than 100 horse-power at any one point on the railway. If, on the other hand, the entire traffic on the line must be concentrated at any one time in a single car or train, then the electrical conductors and distributing apparatus must deliver the full 2000 horse-power at each and every point along the railway in succession. In other words, with the concentrated load the capacity of the distributing apparatus at each point on the railway must be twenty times as great as the capacity when twenty cars are used to haul the same total load.

The application of electric traction on steam railways may thus involve a prohibitive capacity in, and expense for, distributing apparatus, unless the traffic can be divided among many separate cars or trains following one another at frequent intervals.

But it is quite clear that through passenger traffic, and more especially



ONE OF ELEVEN 900-H. P., 55-TON ELECTRIC LOCOMOTIVES ON THE PARIS-ORLEANS RAILWAY FOR TERMINAL TUNNEL AND STATION SERVICE NEAR THE QUAI D'ORSAY, SUPPLIED BY THE COMPAGNIE FRANCAISE THOMSON-HOUSTON

through freight traffic, cannot be economically carried on by a large number of separate cars or small trains. This is so because the expense of operation per train, especially as to labor, goes up much less rapidly than the size of the train or the weight of its load. In recognition of this fact, the number of cars and weight per train on steam railways, particularly in freight traffic, have long been on the increase. According to the reports of the Interstate Commerce Commission, the average number of tons per freight train in the United States was 175.12 in 1890, but stood at 270.85 in 1900.

If electric traction is to be substituted generally on steam roads, it seems certain that the electrical equipments must handle long, heavy trains, some hours apart, as steam locomotives do now. The vital question is whether the necessary investment in electrical equipment will be prohibitive. It may be assumed for present purposes that the first cost of generating stations and of electric locomotives or car equipments is not a serious obstacle to electric traction. The discussion must, therefore, turn on the cost of conductors and distributing apparatus between power stations, or sub-stations, and the railway lines.

It is obvious that stations must be far enough apart so that with concentrated traction loads and infrequent trains each station may work during a great part of each day. Taking the railway 100 miles in length, let it be assumed that trains which require 2000 horse-power each will pass over it, one at a time. Let the power station for this railway be located at one end, so that the distribution apparatus must deliver 2000 horse-power at successive points along the line to the end, 100 miles distant. Can any known system of electric traction be applied here with a permissible investment in apparatus for the distribution?

The most common electric traction system, in which continuous current is generated at about 600 volts in the power station and is distributed over line conductors and the rails to the car motors, can have no application in this case, because the weight and cost of such conductors for a transmission of 100 miles are absolutely prohibitive.

To avoid excessive cost of line conductors, the system with alternating current, developed and transmitted at high voltage to sub-stations along the line of the railway, is being extensively applied. From these sub-stations continuous current at about 600 volts passes over the trolley wire and rails to car motors. Each sub-station, like a generating station of equal voltage, can serve with economy only a few miles of track, say, five at most, in each direction from it. With distributed traction loads this system works well, because each sub-station finds its load of cars on the section of track nearest to it, and the capacity of a sub-station need be only a small fraction of that at the generating station.

If this system, with high-voltage transmission and continuous-current sub-stations, be applied to the railway 100 miles long on which moves a single train, the capacity of apparatus at sub-stations becomes excessive. Even if only ten sub-stations are employed, each operating the train while it is on 10 miles of track, the combined capacity of sub-stations must be 20,000 horse-power. This capacity results from the fact that each sub-station must operate the 2000 horse-power train over a distance of 10 miles. Neglecting, for the moment, the cost of high-tension transmission lines to sub-stations and low-tension feeders to trolley wire and track, it can hardly be expected that steam railway managers will install a generating station of 2000 horse-power and sub-stations of 20,000 horse-power, in order to operate a 2000 horse-power train over 100 miles of track.

On the Continent of Europe quite a number of electric railways are being operated entirely with alternating current used in induction motors. The usual practice is to develop the current at any high voltage desired for the transmission, and then lower it to between 400 and 750 volts at transformer stations located at intervals along the railway. Such transformer stations do not require the services of attendants, as do sub-stations that deliver continuous current, and they save the cost of rotary converters.

From the transformer stations low-tension feeders pass to the trolley wire and track in a way similar to that where continuous current is distributed. In order to cut down the cost of low-tension feeders as much as possible, these transformer stations are usually located at much shorter intervals apart than sub-stations with rotary converters would be. Thus, in the United States rotary converters for railways are seldom placed less than 10 miles apart, while on the Burgdorf-Thun Railway, in Switzerland, a good example of traction with induction motors, there are fourteen transformer stations on a line only 25 miles long. The stations are thus less than 2 miles apart.

On the railway just named the voltage at the generating station is 16,000, and the transformer stations reduce this to 750. During each day twenty-four through trains pass over the entire length of the line, and there are also several local trains on a part of the line. Each train requires 225 kilowatts, and each transformer station has a capacity of 450 kilowatts, so that two trains can be operated at once on each section of track. Plainly this railway presents a case of distributed traction loads, so that the total capacity of transformers can be kept within permissible limits.

To avoid excessive investments in sub-stations, higher voltages are being adapted for the distribution to cars and trains.

On the electric railway connecting Lecco, Chiavenna and Sondrio, in Northern Italy, the distribution of current is at 3000 volts from the transformer stations to the three-phase

OVERHEAD CONDUCTORS AT THE AUSTERLITZ STATION AND TUNNEL OF THE PARIS-ORLEANS RAILWAY

AN ELECTRIC LOCOMOTIVE BUILT FOR THE PHILADELPHIA & READING RAILROAD BY THE BALDWIN-WESTINGHOUSE COMPANIES, PHILADELPHIA AND PITTSBURG. THERE ARE FOUR 50-H. P. MOTORS. WEIGHT OF LOCOMOTIVE, 47,000 POUNDS. SEE PAGE 430

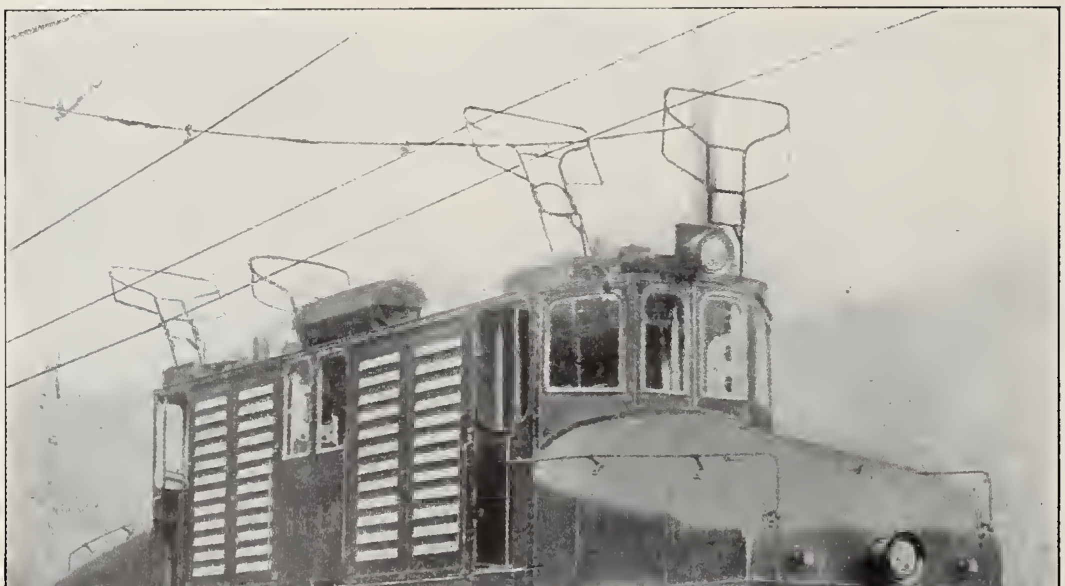
motors on the cars. The total length of this railway is 65 miles, and there are twelve transformer stations, so that their average distance apart is 5.5 miles. Each transformer feeds a definite section of the line and each passenger car carries motors with a capacity of 600 horse-power. The generating station of 7400 horse-power works at 20,000 volts and the transformer stations reduce this to 3000 volts, current at this pressure entering the car motors.

In 1899 and 1900 tests were made on the Teltow road, in Germany, of a system in which three-phase current at 10,000 volts was delivered to the cars and there transformed to about 650 volts for the motors. Following these experiments, the 15-mile railway from Zossen to Marienfeld, with 10,000 volts on the trolley line and a transformer on each car to reduce the pressure for its motors, was constructed. The motors on each car of this railway have a normal rating of 1000 horse-power, and can be worked up to 3000 horse-power. Three-phase current and induction motors are in use on this line.

On the single-phase railway, 11.5 miles long, that runs through the Stubai Alps, in Austria, the voltage of 10,000 at which current is delivered by the generating station is transformed to 2700 volts at a single sub-station and then distributed to the cars.

Near Berlin, the Niederschönemeide-Spendersfeld Electric Railway, using series repulsion motors of the Winter-Eichberg type, has been operated for more than a year with a trolley voltage of 6000. Each motor car on this railway has two motors of 100 horse-power capacity, and the magnet windings of these motors take current at the full trolley voltage, while a transformer on the car reduces the armature pressure to a maximum of 190 volts.

Motors of the same type are in use on a railway at Stubaithal, in the Austrian Tyrol, and in this case the trolley voltage of 2300 is reduced to a maximum of 525 volts by a transformer on the car for both the magnet and armature windings. By the construction of



A 50-TON ELECTRIC LOCOMOTIVE FOR HEAVY, SLOW-SPEED, COAL TRAIN SERVICE BETWEEN ST. GEORGES DE COMMIERS AND LA MURE, SWITZERLAND. THERE ARE FOUR BOW TROLLEYS TAKING CURRENT AT 1200 VOLTS FROM TWO OVERHEAD WIRES. BUILT BY THE ELECTRICAL & MECHANICAL INDUSTRIAL CO., GENEVA

both sets of motor windings for this voltage the cars are enabled to operate in the streets of Innsbruck, where the regular trolley voltage will be about 500.

Perhaps the most ambitious and important application of high voltage to trolley line distribution is that made by the Oerlikon Company on a railway about 12 miles long, in Switzerland. This line was built for experimental purposes in order to bring about the adoption of electric traction on the steam roads of Switzerland. Each electric locomotive on the road carries a single-phase synchronous motor, connected mechanically to a direct-current generator, and this motor is driven by current from a 15,000-volt trolley line. Direct current from this generator drives the car motors, and the speed of the latter is varied by changing the current in the magnet winding and thereby the voltage of the generator.

In the United States, the principal, if not the only increase of trolley voltages, is being made in connection with the single-phase railway motor. One of the great electric manufacturing companies is said to have motors of this type with an aggregate capacity of nearly 12,000 horse-power now under contract and construction. These motors are said to range from 50 to 150 horse-power in individual capacity at 400 to 700 volts, and the trolley wires from which the energy for their operation will be drawn are to have voltages of 1100 to 3300. It is said that substantially all of these motors are to be used on suburban or interurban lines where the speeds will reach 60 miles per hour, and where the traffic approaches steam railway conditions.

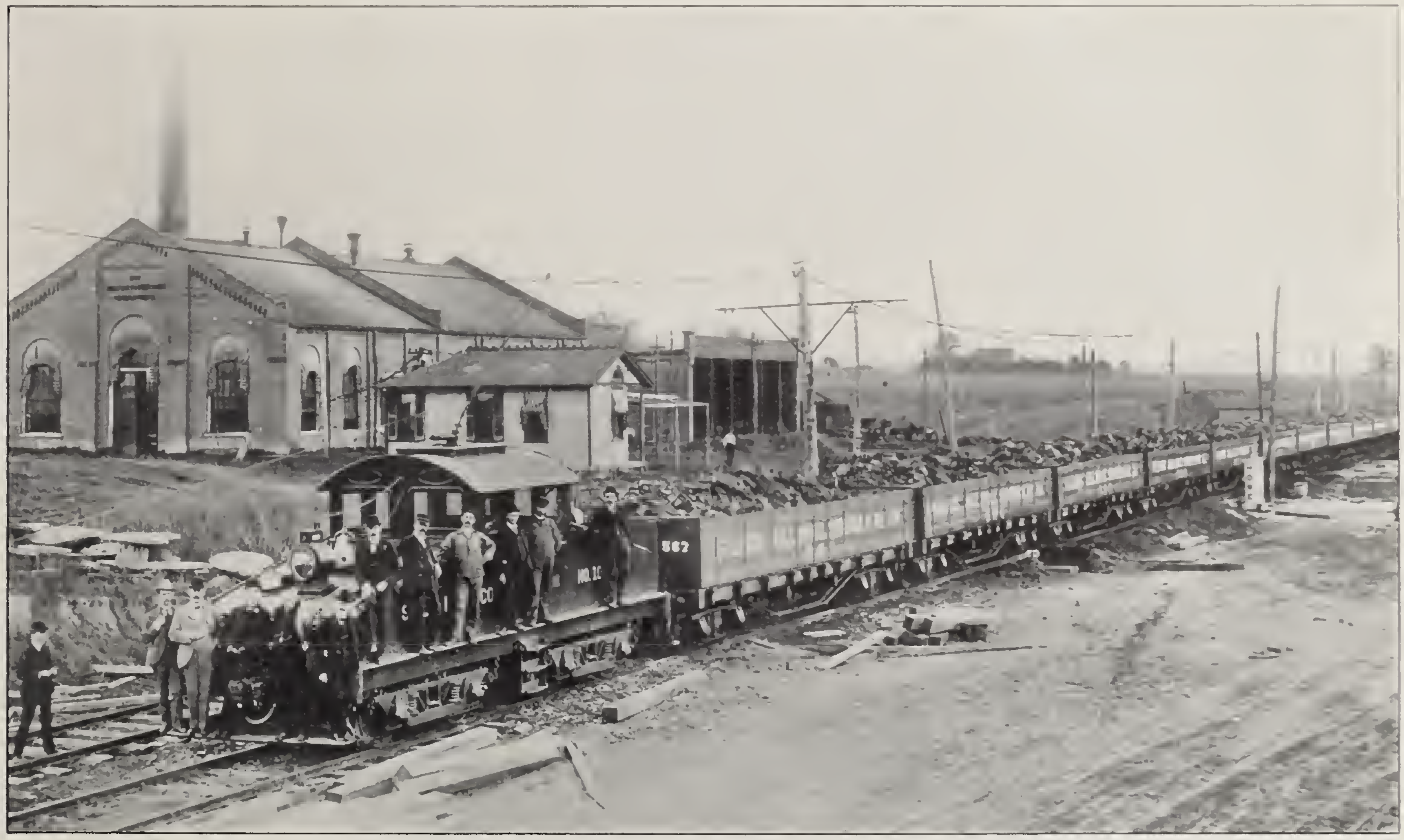
This general movement toward higher trolley voltages is really a recognition of the fact that the supply of long railway lines and comparatively infrequent cars or trains simply raises the problem of long-distance transmission over again. For lighting and stationary motor loads the problem has been solved, as everybody knows, by the use of high-voltage transmission and low-voltage distribution from transformers, and the same system has been extensively applied to railway loads, as above noted.

As long as these loads are well distributed, so that one car moves within the range of each group of transforming apparatus before all other cars are out of range, the required investment is moderate. With stationary loads the transforming equipment is always nearby, and the same condition must be maintained for moving loads, if prohibitive cost of low-voltage conductors is to be avoided. But on railways where the traffic is concentrated in few trains, far apart stationary transforming apparatus can be kept close to the car motors only by repeated duplication along the line, and this again is prohibitive in the matter of investment.

Plainly, only one expedient remains; when the loads are moving and far apart, the transforming apparatus must move with each load, if excessive duplication is to be avoided. If the transforming apparatus moves with the load, or train, the contact between this apparatus and the transmission line must be a sliding one, and this is the high-voltage trolley line.

These considerations make it evident that the mere invention of new types of electric motors cannot solve the problem of electric traction on steam railways, where the traffic is concentrated in few trains. The vital requirement for the solution of this problem is not new types of motors, but a trolley line that delivers the high-voltage current to transforming apparatus that moves with the load,—that is, with the car or train. With such a trolley line, direct-current motors, or single-phase, two-phase or three-phase motors will do the work of electric traction with a moderate investment on any steam railway, no matter how concentrated the traffic may be.

No doubt some of these types of



A 50-TON ELECTRIC LOCOMOTIVE ON THE ST. LOUIS SUBURBAN RAILWAY

AN ELECTRIC LOCOMOTIVE FOR FREIGHT SERVICE ON A 2-MILE LINE OF THE HOBOKEN, N. J., RAILWAY, WAREHOUSE AND STEAMSHIP CONNECTING COMPANY, EQUIPPED WITH FOUR 150-H. P. MOTORS. BUILT BY THE GENERAL ELECTRIC CO.

motors are much more desirable for traction purposes than others. Thus the direct-current and the single-phase motors with commutators require only a single trolley wire, and have much greater starting torque than two and three-phase motors of equal weight. But either of these types of motors will haul concentrated traffic without an excessive investment in either conductors or transforming apparatus, if the trolley voltage is made high enough. The higher this voltage, the greater may be the distance between sub-stations along the railway line, for a given weight of trolley feeders and conductors.

If the voltage of the generating station is carried to the moving cars or trains, and all stationary sub-stations avoided, the condition of minimum investment in both transforming equipment and line conductors is reached. With single-phase motors this condition requires one kilowatt of transformer capacity for each kilowatt of motor capacity.

On the railways now operating with single-phase motors in Europe, and on those under construction for such motors in the United States, there are transformer capacities several times greater than the capacities of car motors, because the voltage delivered by the generating station in each case is reduced by stationary transformers along the line. If these stationary transformers are used at all, their minimum capacity must at least equal that of all the motors on the railway at any one time, and if the traffic is concentrated in a few trains far apart, the total transformer capacity along the line must be many times that of the operating motors, unless their secondary voltage is very high.

If trains are equipped with direct-current motors, and the generating station delivers high-voltage alternating current to the trolley line without intermediate sub-stations, there must be two units of transforming and converting apparatus on the car for each kilowatt in capacity of motors. This transforming and converting equipment may consist of either a static transformer and rotary converter, or of a synchronous motor driving a direct-current generator; but the latter combination is the more desirable. This direct-current generator, when operated at variable voltage by changes of the current in its magnet windings, enables the car motors to be operated at variable speed, just as the auto-transformer does for the single-phase motor with commutator.

For typical steam railway traction, where the entire traffic is concentrated in few trains far apart, either the single-phase commutator motor, or the ordinary direct-current car motor, fed through a motor-generator, will operate with ample power of acceleration and good efficiency, on a moderate investment for equipment, if all transforming and converting apparatus is located on trains, stationary sub-stations are abandoned and generating stations of high voltage connect directly with the trolley wire.

Oil Engines vs. Steam Engines for Driving Electric Generators

According to "The American Machinist," a marked saving in fuel expense has been obtained by the substitution of oil engines for the steam engines driving the generators of the Key West Electric Company, of Key West, Fla. The fuel bill of the company has been reduced from over $24,000 per annum to under $6000. This company is said to have been the first corporation to make use of the internal combustion engine in operating a trolley line.

The enormous gain from the use of the oil is partially explained by the previous extravagant or wasteful use of the coal. The plant consumed upon an average of 5 pounds of coal per kilowatt-hour and the coal cost $5 per ton. The water supply was very bad and the maintenance of boilers and condensing apparatus was troublesome and expensive. The oil now used costs 3 cents a gallon, and the consumption is 0.7 pound per kilowatt-hour.

The Telephone in a Lumber Region

A recent innovation which is greatly appreciated by the lumbermen in the vicinity of the Kennebec River in Maine, says "The American Telephone Journal," is a telephone line which runs from the Forks of the Kennebec through the deep woods to Moosehead Dam and up the Dead River. By means of this telephone service, the pitch of water and the movements of logs can be made known and controlled, whereas formerly when it was desired to have the gates of the dam closed or log-sluicing stopped it was necessary to send messengers through the woods—a long and hard journey, with the messenger often arriving too late to do any good.

The Schenectady Railway Company, of Schenectady, N. Y., has opened an evening school at the rooms of the Schenectady Railway Benefit Association for its employees. There are classes in mathematics, drawing and electricity.

Worm Reduction in Electric Tramway Equipments

A recent test on the Seebach-Oerlikon-Zuerich electric tramway of an electric car equipped with worm reduction gear, is described by O. F. Dimon in "The Electrical Review," of London.

The main features of the new equipment, besides the improved worm gear with its ball thrust bearings, were the flexible and insulated connection between the worm and the motor shaft, the insulation of the motor itself, and the position of the motor at the side of the truck, making it accessible from the side without the use of pits. The two motors were insulated from the suspended frame of the truck, and developed 20-H. P. each, measured at the tire, while running at 1200 revolutions per minute at a standard speed of 9½ miles an hour.

Besides the wear and tear question, which is sure to turn out to the advantage of the worm reduction gear, it has already been possible to ascertain that the worm reduction car runs more smoothly than the cars with spur gear and, besides this, without noise from gears, and without the hammer blows caused by the heavy motors being rigidly journalled on the car axles. Moreover, with exactly the same controllers, the transition from one speed to another is smoother, which is accounted for by the higher speed and lighter mass of the motor.

The energy consumption tests have shown that there is practically no difference between the two systems in this respect, which means that the overall efficiency is the same. The greater efficiency of the higher speed motor makes up for the small deficiency in the worm compared with the spur gear.

When the car is running down grade by its own weight, the efficiency (backward) of the worm is less than that of the spur gear. The difference is illustrated by the fact that the worm gear car will start running down a grade of 1 in 100, while the spur reduction car will start on only ¾ in 100, track conditions and car weights being equal. This backward efficiency is of quite secondary importance, and would only have to be taken into consideration if the use of regenerative principles were contemplated. On the other hand, it reduces the tendency of the car to race away.

The Telegraph Battalion of the Royal Engineers of Great Britain have been conducting experiments with a wireless telegraph system devised by Sir Oliver Lodge and Dr. Alexander Muirhead.

Electricity in Textile Mills

By CHARLES ROBBINS

From a Paper Read at a Recent Meeting of the New England Cotton Manufacturers' Association

THE importance of constant speed in spinning and weaving is well known. Good work and a maximum production depend upon constant speed, and it is the universal opinion that should the smallest variation in speed take place in the engine or shafting it will seriously affect the operation of the spinning and weaving departments.

When the first alternating-current generators were built and operated in connection with existing steam engines, it was found that a single machine would operate with entire satisfaction; when, however, it became necessary to operate two machines together for increased capacity, or in what is technically known as "parallel," there developed conditions which caused a periodical transference of the load from one generator to the other. Electrically speaking, this is known as "hunting."

After carefully investigating the causes which produced this result it was found that the engines had a periodical variation in rotative speed during each cycle of operation. This trouble was due to the angularity of the connecting rod and to the extreme variation of torque upon the shaft at each piston stroke. This condition led to the study of the subject by engine builders, so that at the present time they are able to furnish engines for driving electric generators which do not vary more than 1-30 of a degree from absolutely uniform rotation, and which are usually heavier and of a higher speed than found ordinarily in mill work. This "hunting" in a mill engine is similar to a see-sawing process, a surging forward and backward, which is still further amplified by belting, and when transmitted to the spinning frame has a tendency to break the threads and results in a decreased production of yarn.

It is evident, therefore, that an engine or turbine for operating an electric generator will furnish a more uniform and a steadier speed than the regular mill engines, and that if this uniform speed is available at the spinning frames and looms an increased production with a more uniform quality of work must result. In so far as observation goes this is true. Electrically-driven mills undoubtedly turn out more work and of a better quality than those driven by mechanical means.

The ideal power plant is one so laid out that each unit is working at its maximum efficiency at all times, requiring a minimum amount of attendance, occupying the least possible space, and at the same time of such a design that it may readily be extended and when so enlarged have any or all generating units supplying power to any and all points, irrespective of location of power, demand or distance. This condition is best met by electric transmissions.

If electricity is adopted as a method of transmitting power, the plant may be installed at the most convenient point, which may or may not be attached to the buildings, or it may be placed any reasonable distance from the mill, thus permitting the mill to be located at a point which is most desirable on account of land, transportation, help, light, and the like, whereas the power plant may be installed with a view to its location as a power generating station, irrespective of the point at which the power is to be used, thus rendering available many water-power developments which could not otherwise be used commercially.

The units used in an electric power plant may be installed of the right capacity to do the work in hand. All future extensions may be made when required without altering or in any way disturbing the original installation, and future additions will work together, each unit operating its share of the load in proportion to its capacity. Often this increase in units will not require an increase in attendance. If desired, the initial installation may consist of two units, each of sufficient capacity to normally carry from 70 to 75 per cent. of the total load at its most economical point of operation, and in the event of an accident to either of the prime movers the remaining one could, by reason of its overload capacity, carry the entire demand for power until such time as repairs are made on the damaged units.

The space required by the engine-driven electric generator is but very little larger, in fact, usually no larger than a similar Corliss type of engine, and if the steam turbine is used, much smaller. With the turbine the foundations will be considerably less than with the Corliss engine equipment. The necessity for belt towers, heavy main shafts and belts, and all of the details which go with a rigid, belted system are avoided, as well as the loss of power consumed by these belts and shafts, permitting lighter walls and lighter details of building construction.

The enormous use of electricity as motive power in street railways, in industrial establishments of all kinds and by electric lighting companies demanded the most economical generation of power in the prime mover, and to-day engines and steam turbines are in operation using much less steam per horse-power than was considered possible a few years ago. Therefore, it is fair to credit the use of electrical power with some of the great improvements now existing in steam apparatus.

Owing to the intimate relation existing between steam turbines and electrical distribution of power, it seems proper that we should discuss briefly this subject of steam turbines. The steam turbine was first commercially developed by the Hon. Charles A. Parsons, in England, in 1884, and within four years turbines of an aggregate capacity of about 4000 H. P. were in operation. Up to the present time, approximately 200,000 H. P. are in operation throughout Great Britain. It was not until 1898 that the Parsons turbine was introduced in America by the Westinghouse Machine Company. A conservative estimate places the combined use of turbine generators now installed at about 300,000 H. P., with one-half million horse-power additional ordered.

The turbine development is by no means confined to a single company, it having been taken up in the United States by several manufacturers, two of whom were organized to manufacture steam turbines only, the other companies having been manufactur-

ing steam engines. It will, therefore, be seen that the engine builders realized the rapidly increasing demand for steam turbines, which in the end will materially affect their production of reciprocating engines, and for this reason they are taking up this form of prime mover.

The partial success of the steam turbine as a power-generating device lies in its extreme simplicity, it having a rotary motion without reciprocating parts, and, owing to the high speed at which the turbines run, the moving elements are made much lighter than those existing in steam engines of equivalent capacity.

An important detail in connection with the turbine is that no internal lubrication is required, consequently the condensed water may be returned directly to the boiler; thus, the cost of feed water and the necessity for a purifying process is eliminated. It follows, therefore, that considerable saving in operating expenses is made as well as the item of cylinder oil, while the cost of bearing oil is really insignificant.

In a particular instance in which data have been obtained, after several years of operation the cost of oil for a 600-H. P. turbine is approximately 5 cents per day of twenty-four hours, which is hardly 10 per cent. of that usually required by a reciprocating engine of equivalent capacity.

The space occupied by the horizontal type of turbine generator is about 0.6 of a square foot per electrical horse-power, or, to state it in another way, approximately two-thirds of that required by the vertical type and one-fifth of that required by the horizontal type of piston engine of the cross-compound Corliss type operated in connection with a condenser. The height of the turbine is about two-thirds the height of the horizontal and three-tenths of that of the vertical engine.

Owing to the uniform rotary motion and perfect balance of the turbine generator, a foundation of only sufficient size and depth to support the weight of the outfit is required, foundation bolts not being necessary. It is, therefore, apparent that a very large saving in the cost of turbine foundations is made when they are compared with those of Corliss engines of either vertical or horizontal type.

The steam economy of the turbine is another of its important factors and it is well to know that this does not vary much with the size of turbine. A further feature which is of considerable importance in some classes of work, perhaps not pertinent to cotton mills, is that from half-load to 125 per cent. load the steam consumption is almost a straight line.

In a recent test made on a 600-H.P. Westinghouse Parsons unit by a well-known firm of engineers some interesting performances were shown, and as it is fairly representative of the operation of the steam turbine, we have made some extracts from this test.

When operating with 26.9 inches of vacuum and with dry saturated steam at 150 pounds pressure a water rate of 14 pounds per brake horse-power was observed. By increasing the vacuum to 28 inches, the water rate was decreased to 13.63 pounds per brake horse-power, and was further lowered to 11.17 pounds per brake horse-power by the use of 180 degrees, Fahrenheit, superheat. It will be seen that the gain due to 1.1 inches of vacuum at full load was 2.4 per cent. and the gain attributable to 180 degrees of superheat, 10.5 per cent.

The thermal efficiency obtained in this test for dry saturated steam was 17.22 per cent., and under the same conditions with superheated steam, 19.43 per cent.

In another test, under regular operating conditions on a 1500-K. W. turbo-generator, the steam consumption was found to be 14.23 pounds per electrical horse-power, and the corresponding coal consumption (with Georges Creek "run of mine" coal), 1.23 pounds per electrical horse-power, using steam at 155 pounds pressure, 42 degrees superheat and 27 inches vacuum.

In still another test on a similar turbine, with 28 inches vacuum and 140 degrees superheat, a water rate was obtained of 12.66 pounds per electrical horse-power, which is equivalent to 10.75 pounds per indicated horse-power on the basis of a total efficiency of 85 per cent. for the generator and steam engine.

It is a well-known fact that steam-engine economy is dependent upon the excellent condition of the engine, and to maintain this condition it is necessary to take frequent indicator cards and to make adjustments of valves, piston heads and the other parts. The economy of the steam turbine does not seem to be affected by years of use. Observation has shown that there is practically no wear on the bearings whatsoever, seeming to show that the friction load in the turbine is very small.

A well-known engineer and operator has characterized the steam turbine as "fool proof," and we believe that experience shows that undoubtedly it is the simplest form of prime mover extant, and therefore ought to be of interest as a means of power generation where it is desirable to lessen the cost of power and attendance.

Owing to the small size of steam turbine generators, the cost of building and the space occupied are materially lessened as compared with other forms of engines and generators, and it is interesting to note that a great many manufacturers have installed turbine generator auxiliaries in connection with their main steam engines in a space which, while sufficient for the turbine outfit, was inadequate for a new engine.

The turbine generator offers opportunities to many operators of cotton mills to increase their power facilities without increasing their engine room space. In some manufacturing establishments it has been found desirable from the point of economy to retain a portion of the present direct steam engine drive and install additional power by means of electricity, operating distant or outlying loads by electric motors. This provides means for shortening long lines of shafting, eliminating angle or other difficult mechanical drives, thereby decreasing friction losses and materially increasing the plant economy.

Coming to the distribution of power to the different departments in the mill, it is to be noted that the transmission system consists of small copper wires of suitable diameter to carry the necessary power. These wires, when once installed, are permanent, they require no maintenance and do not require special provision for supports. It is obvious that this method of transmitting power is one of great flexibility, and the use of electric motors permits the exact amount of power necessary to be applied at the very point where required.

The alternating-current motor has the widest use in textile mills for the reason that its design is so simple: in fact, it consists of only three main parts, the stationary portion, the revolving element and the bearings. There are no moving electrical contacts, and as a consequence the only attention required is to keep the motor clean and to properly fill the self-oiling bearings.

One of the characteristic features of an alternating-current motor is its automatic regulation, requiring power only in proportion to its output and being capable of sustaining, should occasion demand, large overloads without injury. Owing to the inherent design of this type of motor the uniform rotative speed of the prime mover is available at the work just as though it were directly geared, and thus a gain is made in production re-

sulting from a steady and even speed.

The question of sub-division of line shafts is one that is best disposed of by taking up each individual case and selecting motors of such capacity that a minimum amount of belting and auxiliary shafting will be required, at the same time reducing the friction to as low a factor as is consistent with a proper financial outlay.

Where the electric system is used, a factor of value in some instances is that if a breakdown should occur, only a small portion of the mill would be affected, and such sections as it may be desired to run independently can be so operated without respect to any other and without operating main drives, as is found necessary with a mechanical system.

On account of the general improvement in textile machinery, many mills have found that an increased production could be obtained by running their machines at a higher speed, involving an increase in the speed of the line shafts. While this can be accomplished successfully by changing pulleys, the increased speed means an increased demand upon the engine, and oftentimes, due to the lack of capacity, this condition could not be complied with on account of the increased cost all along the line. If electric motors were used for driving the shafting it would be a small matter to change the size of the motor, and if the increase in speed is general it may involve an increase in the power house, which can be accomplished by the addition of a new generator unit much more readily than by changing the engine in a mechanical drive.

In a small mill where it is known with a fair degree of accuracy that the conditions will not change, and where the character of the product is such that no change in speed will take place, a mechanically-driven mill with a centrally located steam engine will undoubtedly be as economical as an electric installation, and its initial cost will be less. But with the improvements in textile machinery, the higher speeds and the changing market there are but few men who believe such a mill is representative of the industry.

In other instances mills are laid out with a view to extensions, and on account of the inflexible conditions existing in engine-driven mills a large engine has been installed, operating at from 50 to 60 per cent. of its rated capacity, which sometimes means that a single cylinder of a cross-compound engine is installed and that during the early operation of the mill the power plant must be running at an uneconomical load, which, of course, greatly increases the cost per horsepower per year. The main shaft and transmission details must be of such a capacity that they will transmit the whole power should occasion demand it in the future. This involves a large initial outlay upon which interest, depreciation and insurance are increasing the operating cost per horsepower.

There are other mills consisting of a number of buildings, each having its own power plant and inflexibly connected to its own lines of shafting, and therefore unable to supply power to any other building or to help out in the event of other engines being underloaded, overloaded or disabled. Thus, some of the power plants are running at uneconomical loads together with increased attendance, repairs and maintenance. The several plants also require space that might be profitably used for manufacturing purposes if a single power plant were possible, as with the electric drive.

A matter which may prove of some interest is that recently there has been placed upon the market a variable-speed, alternating-current motor, suitable for the operation of cloth-printing machines, tentering machines and drying cans. The speed control is accomplished in the motor and is much simpler than previous methods of electrically operating the above class of machines; particularly is this true of printing machines.

It is a well-recognized fact that good lighting is an essential consideration in the manufacture of textile materials and goods in general. This is particularly true of the weaving shed, where special attention is always given to proper lighting effects, and where saw-tooth roof construction is frequently used. You are all doubtless familiar with the arc lamp and incandescent lamp; it will, therefore, not be necessary for us to discuss this form of illumination. But attention may be called to a comparatively recent development in the art of electric illumination,—the Nernst lamp.

This form of lamp is well adapted to the lighting of cotton mills on account of its pure white light, which resembles daylight, and its steadiness and cleanliness. The lamp was primarily designed for operation on alternating current, and it is especially adapted to the varying conditions which exist in textile manufacture, on account of its flexibility in candle power, the range of units being from 25 to 500 candle power. This flexibility permits the proper choosing of units so that a uniform quantity of light may be had throughout the mill.

The efficiency of the Nernst lamp is about double that of the incandescent lamp and is approximately on a par with the arc lamp, and since it is designed for operation on 200 to 220-volt circuits, the cost of electrical conductors is considerably less than for incandescent or arc lighting.

Very large installations of Nernst lamps have been made in textile mills, office buildings, art galleries, dry goods stores and other places where the quality of the light is the first consideration.

One further word in connection with illumination:—Experience has shown that when due attention is given to proper lighting effects the quality of the work produced is superior and the amount is in excess of that in establishments which are not properly illuminated.

The Census of 1900 contains a report of 98½ per cent. of all concerns engaged in cotton manufacture, showing that these concerns use approximately 800,000 H. P. There are now in operation in textile mills, electric motors aggregating in capacity 140,000 H. P. It will, therefore, be seen that in view of the comparatively recent introduction of the electric motor in this industry it is making rapid strides as a means of power transmission.

Electric Locomotive for the Philadelphia & Reading Railroad

THE Philadelphia & Reading Railroad Company recently purchased from the Baldwin Locomotive Works, of Philadelphia, an electric locomotive for hauling freight on one of the company's lines.

The machine is mounted on two trucks and has a motor on each axle. The driving wheels are 30 inches in diameter and the locomotive weighs 47,000 pounds. With a full load a speed of 10 miles an hour can be attained. The equipment consists of four 500-volt Westinghouse street railway motors of 50-H. P. each. There is a Westinghouse magnetic blow-out controller and the cab is fitted with electric heaters. The trolley wire is suspended on one side of the track instead of directly over it. An illustration of the locomotive is given on page 424.

The largest electric freight locomotive yet built in England is to be used on the electrified section of the North-Eastern Railway, near Newcastle. It is capable of hauling a train of 300 tons weight at a speed of 14 miles per hour.

In 1903 the copper mines of Lake Superior yielded 192,299,485 lbs. refined copper, being about 15 per cent. of the world's production.

The Increasing Use of the Telephone

With Particular Reference to the Private Branch System

By H. S. WEBB

THE use of the telephone is spreading rapidly, and both the manufacturers of telephone apparatus and the telephone exchange companies are prepared to meet the demand for telephone systems for almost any purpose. There are very few office buildings, hotels, apartment houses or large business establishments that have not a private branch switchboard connected by a number of trunk lines with the nearest city exchange. By means of this switchboard any telephone in the establishment may be connected with the city exchange. Systems of this character are usually installed and maintained by the telephone exchange company for a yearly rental, although the operator of the switchboard is employed by the owner of the building or of whatever place in which the system may be installed. In New York City there are more telephone operators in private branch exchanges than in all the central exchanges in the city.

A private branch system gives excellent satisfaction and has become almost a necessity in establishments where each telephone must be provided with the city exchange service. In office buildings, most of the messages are for concerns or individuals outside the building, and only a small percentage of the office telephones are in use at the same time. A few trunk lines, therefore, will give satisfactory service for a much larger number of instruments. As the underground cable systems in cities like New York are very expensive to install and maintain, it is desirable to use no more lines than necessary between the central exchange and the office building. A private branch system entails no care on the part of the subscriber, as all troubles are reported by the operator directly to the company, who remedy whatever faults may arise.

The large department stores have long used private telephone systems, connecting the various departments. Now, many of them are installing private branch systems. In Chicago, for instance, one department store is equipped with a very complete private branch system, and for 5 cents any customer may be connected with the outside through the central city exchange. Coin slot devices are extensively used in Chicago, and in this particular establishment each instrument is equipped with one, necessitating the insertion of either a 5 cent piece or a token before a connection can be obtained. For business connected with the establishment, employees are furnished with tokens of the same size and weight as a 5 cent piece, but a nickel must be deposited for purely personal communications.

Many department stores do a very large business by means of the telephone; that is to say, many of their women customers have found it convenient to do their shopping over the telephone, saving thereby carfares, time and energy. Stores making a specialty of filling telephone orders have clerks devoted solely to this purpose. These clerks, upon receipt of an order go the rounds of the various departments, making what they consider the best selections for their customers. During the recent street car strike in Chicago, a tremendous amount of business was transacted in this manner. Many shoppers who were forced to adopt this means for the first time discovered its conveniences and have used the telephone since that time.

In Toledo, Ohio, many of the large business houses, offices, factories, the street railway company and the board of education have installed private branch systems. One large dry goods store has five trunk lines to the city exchange, giving telephone connection to thirty-five departments. Four girls attend to the switchboard, and, when a special sale is announced, customers call up the department having the sale, order such material as they desire and the orders are immediately filled and forwarded to the customer's address. During one special sale the operators handled 500 calls, including those from departments. An accurate account of calls received from the outside on a day on which there was no special sale showed 114 calls.

Another use of the telephone is for dispatching trolley cars, Milwaukee, in Wisconsin, and Toledo, in Ohio, in particular, using this method. There is scarcely a point inside of the city limits on the system of the Milwaukee Electric Railway & Light Company that cannot be reached by the telephone within less than two blocks. In the company's office there is an ordinary private branch switchboard with sixty-four lines, as well as a dispatching board with over 111 instruments.

The police department of the city of New York is now a large customer of the New York Telephone Company. This department has probably the highest salaried telephone operators in the world, police sergeants acting in that capacity. It is claimed that girls could not satisfactorily handle the work peculiar to the department, but it is to be doubted that bright girls or young men cannot do a large percentage of the switch-board work, allowing one sergeant to handle all calls to which an ordinary operator could not give an official reply. Experience has shown telephones in police patrol boxes and stations to be much more convenient and flexible than a mere signal system. By means of the telephone, additional policemen can be summoned, as well as the fire department, patrol wagons, ambulances and the like, for all of which purposes a signal system has been found to be inadequate.

In cities well supplied with telephones it has been found that a large proportion of the fire calls are received over the telephone. Telephones have been found much more convenient than those fire alarm systems in which it is necessary to first find the holder of the key of the fire alarm signal box before an alarm can be turned in.

The United States Treasury Department at Washington now has a private exchange system, in addition to a number of instruments, by means of which communication may be obtained with officials in cities of any importance east of the Mississippi River. Nearly one hundred instruments are used in this department.

In order to supply telephone service to those who have hitherto made but little or no use of it, the Chicago Telephone Company have introduced

party line systems and coin slot devices very extensively on their lines. Two, four and ten subscribers are placed on one pair of wires, the number of calls per day at 5 cents each that the subscriber agrees to make depending upon whether the instrument is on a private line or a two, four or ten-party line. It is said that the company finds a number of its ten-party lines very profitable indeed.

While a private branch switch-board undoubtedly gives a large establishment the best all-around service, and is, in many instances, a necessity, still it is very expensive in a number of cases. Large institutions, such as reformatories, prisons, workhouses, poor farms, asylums and hospitals, factories and shipyards, have found it more economical and satisfactory to install their own telephone equipment. While such a system would only be intercommunicating, still, if desirable, one or more instruments may be directly connected with the central exchange in order to obtain exterior communication.

The manufacturers of the apparatus or some installing company will put in an entire system of this kind and turn it over in complete working order. Institutions of the character of those mentioned usually have an electrician who would be entirely competent to take care of the telephone system. However, should the system develop any very serious faults, then it will pay to call in an expert. Systems like those mentioned, if properly designed and installed, usually require but very little care beyond looking after the batteries and ringing apparatus, whose workings almost any electrician ought to be competent to oversee and regulate.

Private switch-board systems of the central energy type seem to give the best satisfaction, but there are several different varieties of this type. For private switch-board systems, the service required does not usually warrant the expensive lamp-signal switch-board, although many partially informed persons will be satisfied with nothing else. In a large city exchange, where a three-second service is frequently required, the conditions, which are somewhat different than in the private switchboard system, generally require the quickest and most economically operated switch-board.

This requirement is undoubtedly best fulfilled to-day by a central energy system, in which all switch-board signals are given by miniature lamps. For the private switch-board, visual electromagnetic signals may be substituted for lamps, thus simplifying the circuits and eliminating all lamps and most of the relays. Such a switch-board will give very rapid service and will cost less to install and maintain than a lamp-signal board.

The signals ought to be self-restoring as well as visual, for a system of this kind costs little or no more than the older, and now out of date, systems in which it was necessary for the operator to restore each signal by hand. In central energy systems no batteries or magneto-generators are required at the telephone stations, the batteries being concentrated at the central office.

The use of the telephone on steamships has developed rapidly within the last few years. Many of the trans-Atlantic steamers are fitted with more or less complete telephone systems by means of which the passengers may communicate with each other from their staterooms, and by which orders may be transmitted between the various departments of the ship. Nearly all war ships are now provided with telephone systems, which enable the commanding officer to speedily transmit his orders to almost any part of the vessel.

Many of the large railroad companies are using the telephone extensively. Some have their own private switch-board systems in addition to their through line systems, on which both telephones and telegraphs are employed. Some railroads lease their exchange systems from the telephone companies operating in the large and important cities on the line of their roads. The railroad companies generally own and maintain the long lines paralleling their tracks. These lines are used for signal, telegraph and telephone systems. In many cases the same wire is used for telegraphing and telephoning at the same time. The telephone is now extensively used by some roads for transmitting train orders. It has not displaced the telegraph to any great extent, but is used in addition or as an aid to it.

The Manhattan Elevated Railway Company, of New York City, installed during the past year a private telephone system with 300 lines, but the switch-board is large enough to accommodate 300 additional lines. It enables the officials to handle the train service much better than formerly. It is a central energy system, the longest possible length of line between two stations being about 17 miles, which is rather a long distance at this time for a central energy system.

There is no reason, however, why a properly constructed central energy system should not work over even longer distances. In fact, it does when two local telephones belonging to central energy systems of different cities are connected through the lines of the long-distance telephone company, although repeating coils are used, in the latter case, at each city exchange. All the outside wiring for the Manhattan Elevated Railway system consists of lead-covered cable carried by galvanized iron wire cable fastened to the elevated railway structure with iron brackets. The central office is as completely equipped as any city exchange of the same size.

The Harlem Jockey Club, of Chicago, has quite a system of telephones, which it uses for managing its races, gates, ticket offices and stables. In London there is a company that supplies theatrical and musical performances by telephone for a small extra price. It recently enabled twenty-four journalists and others to hear in London, through the telephone, a speech being delivered by Mr. Balfour in Sheffield, 140 miles away.

When an establishment does not require more than about twenty telephones, and when these telephones do not have to be connected in any way with the city telephone system, some kind of an intercommunicating house or speaking-tube system, as they are variously termed, will prove satisfactory. Such systems require no central switch-board and no operators. At each telephone there is a switching device of some kind that enables a party at one station to ring the bell at any other station on the system. Such switches are now made more substantial than formerly, and a reliable system of this kind leaves little room for complaint. There are numerous modifications of this type, the latest having all the batteries located at some central and convenient place, the switches being restored automatically to their normal position when the receiver is hung on the hook-switch.

Intercommunicating systems generally require one wire for each station, and, in addition, one or two and sometimes three, extra wires. One of the extra wires is used as a common return for talking, and the others for signaling purposes. All the wires must run through all the stations, and hence the amount of wire required increases very rapidly with the number of stations. Where the stations are rather far apart, about 200 feet or more, and especially if the wires are run in cables, which is decidedly the best way, cross talk is apt to result unless two wires twisted together to form a pair, are used for each station. If there is sufficient cross talk, a third party may take down his receiver and hear the conversation being carried on between two other stations.

This cross talk is generally due to electrostatic induction between neigh-

boring wires running along together for some distance. It is sometimes due to moisture that has soaked into the cable. The same result may also be caused by a third party accidentally or intentionally moving his switch until he cuts his telephone into the same circuit with the two parties already conversing. This can usually be detected by the resulting decrease in the intensity of the sound produced in the receivers. To avoid cross talk due to induction a pair of wires should be used for each station in place of one wire, with a common return for all stations. A common return may, however, be used for the signaling current. For ordinary small intercommunicating systems it is not generally necessary to use a pair for each telephone, one wire for each and one or two common return wires usually being sufficient.

In private dwellings telephones are replacing speaking-tubes, annunciator systems and call bells. It is much more convenient for the lady of the house and much less laborious for her servant for the former to be able to telephone her order to the servant from her room instead of using an annunciator system, which requires the latter to watch the annunciator, reset it, and then go to the proper room for her orders. It is more satisfactory than the speaking-tube, because distance and bends, which reduce the efficiency of the latter, have no injurious effects upon the interior telephone system. Moreover, one can talk and listen at the same time, if necessary, whereas with the speaking-tube, one has to perform a sort of gymnastic feat to get the mouth away from the tube and the ear in its place before the party at the other end gets ahead of one in the reverse operation.

For replacing annunciator systems or speaking-tubes very simple telephone systems will suffice. When communication is desired only between one central point and several points in other parts of the house or estate, it is only necessary to run one common wire through or to all the stations by the shortest or most convenient path, in addition to one wire from the central point to each other point. The batteries may be located in one convenient place, such as the cellar. The instruments may consist merely of small, but very efficient receivers, transmitters and buzzers, with an almost invisible hook on which the receiver is hung when not in use, and which performs all the necessary signaling and switching operations.

Where desirable the whole telephone instrument can be made very compact and placed in a small cavity in a partition wall, and a door, flush with the plaster surface, will conceal it. In small house systems, induction coils are usually eliminated, the transmitter and receiver being connected in series in the line circuit when in use, all current being supplied from primary batteries located in the cellar. By means of a simple rotary switch at one station any of the other stations may be called from that point.

Such a system is also applicable to apartments of medium grade for communication with the janitor, whose income is largely augmented by the errands and work that he performs for the occupants. It is becoming quite customary to provide a telephone between the entrance and each apartment. In this case a transmitter, receiver and push-button are required for each apartment at the main entrance to the building, and a transmitter, receiver and buzzer in each apartment. The telephone in the apartment may also be connected so as to allow communication with the janitor, an extra push-button or an equivalent switch being required for the latter service.

For apartments and dwellings, the telephone systems should be designed and wired so that all current for the transmitters as well as for the bells or buzzers is supplied from one or two centrally-located batteries. Such a system is called a central energy house, or speaking-tube system. One battery may sometimes be used to supply all current, but very often it is more satisfactory to use two batteries, one to supply current for signaling and the other to supply current for talking, because batteries of different voltage may be required for the two purposes.

Many apartments, in addition to the service already mentioned, require a telephone connected directly or indirectly through a private branch switch-board with the nearest city exchange.

Trains are now equipped in some instances, so that the passengers may use a telephone in the car, as long as the train remains at the station, to talk with friends or on business affairs. It is now possible to telephone over very long distances. To the best of the writers knowledge, from Boston to Omaha is about the longest distance over which the public can telephone. Professor Pupin predicts that when his load-coils have been applied to the long-distance circuits, it will be possible to talk from New York to San Francisco. The efficiency of the circuits to which they have already been applied has been considerably increased.

The day does not seem far distant when telephoning will be possible between any cities in the United States, and when the telephone will be used even more extensively and by many more people than at the present time. Its many uses and advantages are being appreciated more and more every day.

Electric Roads vs. Steam Roads in Great Britain.

FROM time to time, says "The Electrical Engineer," of London, the railway companies in Great Britain are reduced to sundry expedients for retaining their suburban traffic against the competition of electric tramways. Reduced rates, zone fares, accelerated services and motor cars are among the remedies to which they have had recourse.

None of these, apparently, appealed to the East and West Yorkshire Union Railway who, in terminating their service between Leeds and the Rothwell district, frankly acknowledge the potency of the electric tramway. The Midland Company has been associated with the working of the system, but latterly the proprietors have had to contend with a loss of £200 per month.

The Great Northern has also experienced the competition and a reduction has been made in its fares. Naturally, the trams are very popular in the summer, and in this respect it is difficult for the trains to compete with them; but now that the Lancashire & Yorkshire and the North-Eastern Companies have shown the way in the electrification of their local lines, perhaps it will not be long before others follow suit.

British Naval Use of the Wireless Telegraph

ACCORDING to a recent statement credited to Signor Marconi, says "The Army and Navy Journal," no matter where a British warship may be on the Atlantic Ocean or in the Mediterranean, the British Admiralty can communicate with it at any moment. Eighty of the British warships, including all of the principal vessels of the Home, the Mediterranean and the Channel fleets, are equipped with the Marconi long-distance wireless apparatus.

The British Government is installing this system as rapidly as possible on all of its vessels. A long-distance wireless communication between England and her most important fortress, Gibraltar, has been in uninterrupted service for many months, despite the fact that besides crossing the English Channel the messages traverse a thousand miles of Spanish territory.

High-Tension Insulators

By V. G. CONVERSE

The best form and the limitations of the high-tension insulator are to-day still doubtful factors in electric transmission, but experiment and intelligent discussion are both helping toward a solution of the problem. An interested welcome is therefore extended to such contributions as Mr. Converse's, which was presented originally at the recent International Electrical Congress at St. Louis. Insulators are one of Mr. Converse's specialties, and what he writes about them makes excellent reading.—The Editor.

It is only fourteen years since 3000 volts were considered a very high tension, and the success of a transmission at this tension was looked upon with far more skepticism than is one of 80,000 volts at the present time. As the steps in high tension have been made with the increasing use of alternating currents, and as alternating-current power transmission dates back only the fourteen years mentioned, the province of this paper may then be considered to be within these limits.

It is a little difficult to trace the early stages in the development of the high-tension insulator. Undoubtedly the first forms were copied from insulators used for telegraph and telephone work. Certain it is that the same styles of insulators were proposed and the same theories were advanced. As the tension or voltage increased, the insulators were made larger and had various petticoats in order to prevent leakage of current. Since it was found in telegraph work that if the surface of the material of the insulators was hygroscopic there was difficulty in transmitting the message, the materials of high-tension insulators were very carefully considered in order that this dangerous hygroscopic condition might not so reduce the effectiveness of the insulator that vital quantities of current would leak over the surface. The same construction for cross-arms, pins, and the securing of insulators, adopted by the telegraph and telephone companies, was adopted for power transmissions, and until a few years the aim was to use such details of construction as had become standard and thus could be easily obtained.

Glass and porcelain are the only materials which have been used extensively for high-tension insulators, although many other materials and compositions have been proposed and tried. At times it has seemed as if one possessed qualities of decided advantage over the other, but a better understanding of the requirements or an improvement in the method of manufacture has brought the other to an apparently equal basis, so that from the first we have had glass insulators and porcelain insulators, and even combinations of glass and porcelain.

The commercial success of high-tension transmissions being until late years in doubt, developments of insulators have been in the improvement in form and materials, no radical changes in construction being ventured; yet every engineer has had his own ideas regarding the details of construction. It would seem as if almost every engineer who has had the opportunity of exploiting his ideas, has done so. As a result, we have had at various times insulators with gutters and spouts, insulators in the form of helmets, some with drip points, and others with every conceivable form and combination of petticoats. The situation has been further complicated by a variety of ties for securing the line to the insulator, pins of wood and of iron, various threads for securing the insulator to the pin, and even by a wide range of colors of material. It is little wonder that the manufacturer of porcelain or glass who was skilled in the art of making tableware and various other utensils, and perhaps telegraph insulators, has hesitated when confronted by the requirements of the up-to-date high-tension engineer.

It should be stated to the credit of the manufacturer that the arts of making porcelain and glass, which have descended to us from periods antedating the Christian era, had reached a certain stage of perfection. Strong and beautiful and satisfactory wares were made, but here was a new requirement. The material of the insulators must be strong to withstand mechanical strains, and it must also withstand the unseen and unknown electrical forces which would tend to break it and render the insulators useless.

The improvements that have been made in glass have been in the direction of strengthening the quality in order to protect against mechanical breakage, the structure of glass already suiting electrical conditions very well. The improvements in porcelain which have been in the direction of strengthening the body of the material to resist electrical puncture have been interesting and are noteworthy. From porcelains, which were first furnished for insulators and would stand but a few thousand volts, the advancement has been in the line of obtaining a more homogeneous, refractory and vitreous grade of material which is strong in resisting electrical breakage. Of recent years the combining of layers of this high-grade electrical porcelain has further strengthened the body of the insulator.

But let us trace directly the forms of insulators which have been used. In 1890 the first alternating-current power transmission in the United States used, for 3000 volts, a glass insulator of the form shown in Fig. 1. This is an insulator such as is commonly used by the telegraph companies and is

FIG. 1

only about 3 inches in diameter. In spite of the predictions that the insulator would not suffice, the plant continued in operation for six years without insulator troubles.

For the famous Frankfort-Lauffen transmission experiments in Germany in 1891, a porcelain insulator with an oil cup was used. No definite information as to the exact shape of this insulator is at hand, but the principle was probably not unlike that of the insulator shown in Fig. 2. Voltages as high as 28,000 to 30,000 were used in these experiments for a limited time. Insulators with oil cups of various forms appeared very shortly afterwards in Great Britain and the United States. If the insulator was of glass, the outer petticoat was usually curved

inward and up so as to form an internal groove which would hold oil.

A common form for porcelain insulators was a petticoat brought down from the body of the insulator which

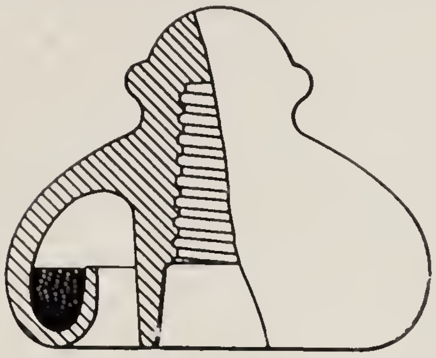


FIG. 2

would dip into a cup of oil, the cup being made in a circular form and held in place around the pin by a support on the pin. Insulators with detachable oil cups were supplied for the 10,000-volt transmission at Pomona and San Bernardino, in California, started in 1892. The oil cups were not used, however, as they were found to be unnecessary.

Insulators without oil cups being equally effective as those with oil cups, a form similar to that shown in Fig. 3, made of either glass or porcelain, came into use. Here the idea was to impede the leakage of current over the surface by introducing petticoats which gave a very long surface between the conductor and the pin. Some insulators had as many as four or five such petticoats.

No further increase in voltage is noted until 1895, when we find the Hochfelden-Oerlikon transmission in Switzerland at 13.000 volts. In 1897 we had transmissions in the United States at 16.000 volts. About this time it was found that porcelain insulators which had been formed and pressed in iron moulds had not a sufficiently compact or homogeneous structure and were apt to be punc-

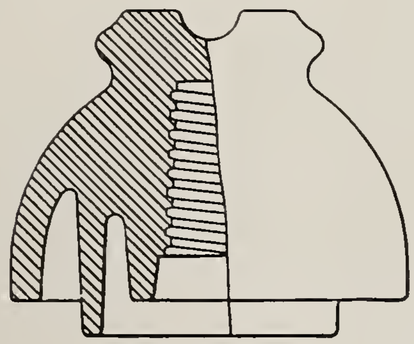


FIG. 3

tured in service. A study of the matter showed that really the only effective dielectric insulation of the porcelain was contained in the glaze over the surface of the porcelain. In some cases it was found that the interior body of the porcelain insulator would actually absorb and hold a considerable quantity of water.

The manufacture of porcelain was then studied with a view to overcoming these difficulties. The method was resorted to of making the insulator in several thin shells which were glazed separately and then glazed and fired together, the potter's wheel being reverted to in order to make the shells of sufficient compactness. This construction is shown in Fig. 4. It will be noted that a petticoat is here extended down for a distance over the pin for the purpose of further insulating from the pin. Attempts had been made heretofore to extend a petticoat down around the pin, but when the insulator was made in a mould no such long petticoat could be made as is now possible when the insulator is made in several parts.

In 1898 we have the first commercial very high-voltage plant in opera-

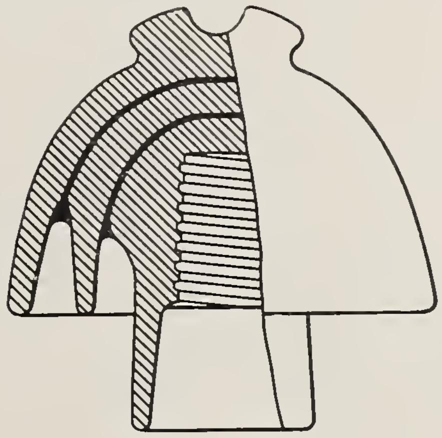


FIG. 4

tion in the United States, at Provo, Utah. This transmission is at 40,000 volts, the insulator used being of glass, shown in Fig. 5. This insulator has outwardly extending petticoats, the purpose of these being to provide unexposed surfaces near the wire in order to prevent surface leakage.

In 1900 the demands of the Bay Counties and Standard Electric Companies of California, for 60,000 volts, made necessary a very much larger insulator than had ever been made before. This is shown in Fig. 6. In this insulator the outer petticoat is carried out almost horizontally, and a gutter is formed on the top near the edge of the petticoat to conduct water away from the cross-arm. The top piece of this insulator was originally of porcelain, and the petticoat around the pin, which now amounts to a sleeve extending down the whole length of the pin, was of glass, the glass and porcelain being secured together by sulphur at first and then cement. This type of insulator has been commonly designated the "mushroom" type, from its appearance. A modification of the outwardly extending petticoat idea is seen in the insulator shown in Fig. 7. This form has had a limited use.

While the insulators enumerated have been referred to in order to show the successive steps in the development of the present highest-tension insulators, it must not be understood that such insulators are not still in use. On the contrary, with the exception of the oil insulator, all of these types, and many others possessing the same essential characteristics, are in service at the various voltages for which they have been found adapted. Even the telegraph insulator shown in Fig. 1 has given good service in certain localities at voltages as high as 10,000.

Insulators of the types shown in Figs. 3, 4, 5 and 6 are in use for voltages as high as 40,000. In various sizes these insulators are used for all intermediate voltages up to 40,000. The types shown in Figs. 5 and 6 are in use in a few cases at 45,000 volts. Some of these insulators have given good service from the first, while others have failed, owing largely, it is believed, to faulty material. In some cases it has been necessary to replace a whole equipment of insulators because of their faulty construction; in other cases a gradual weeding out has been necessary until the faulty insulators were removed. Occasionally we hear of a plant operating where there has been almost no trouble with insulators, except with such as have been broken by outside interference. In general, the feeling is believed to exist that the line-insulator problem

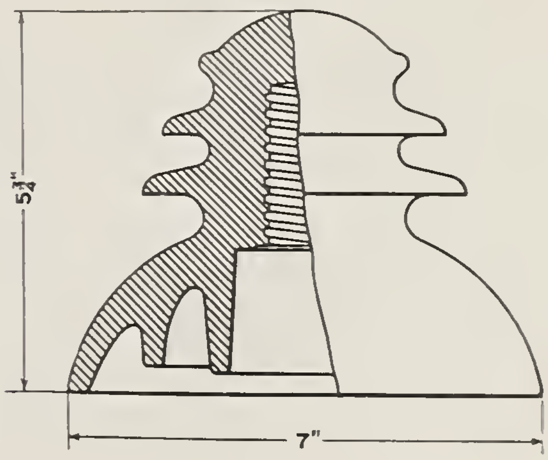


FIG. 5

for voltages as high as 40.000 has been satisfactorily solved.

We are now at the point of consideration of insulators for the very highest voltages—those which are in use for voltages of from 50,000 to 60,000. Fig. 8 shows a glass insulator used by the Missouri River Power Company, in Montana, for 55,000 volts. This insulator has been in service since 1901. The insulator is in two parts,—one a hood, 9 inches in diameter; and the other a sleeve set over the pin. The sleeve, which is open at the top,

adds nothing to the dielectric strength of the insulator, its purpose being to protect the wooden pin. Obviously the sleeve would be of little value if a metal pin were used. This type of insulator possesses the advantage of being in two separable parts, either of which can be replaced if broken.

The insulator used for the 50,000-

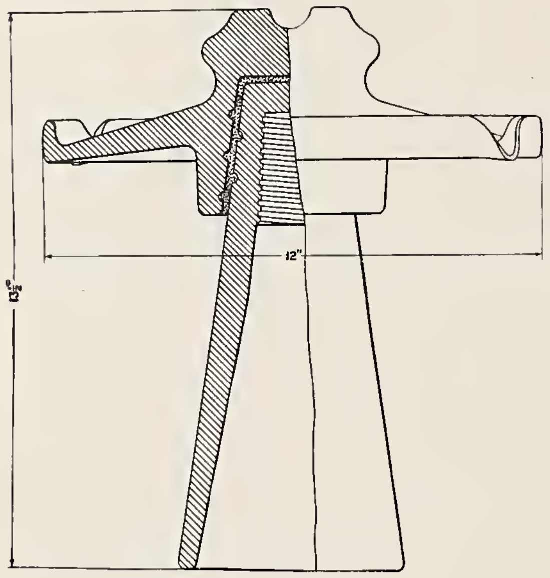


FIG. 6

volt transmission at Shawinigan Falls, Quebec, is shown in Fig. 9. This is of porcelain and made in sections, each of which has a closed top and adds to the dielectric strength of the insulator. Two petticoats, one 9 inches and the other 10 inches in diameter, extend outward and give the effect of one insulator over another. One section extends down around the wooden pin and serves to protect the pin. The sections are held together with Portland cement. This insulator shows the combination of the sleeve around the pin, outwardly extending petticoats, and sections, as first indicated in Figs. 4 and 5.

Fig. 10 shows a very large and extended form of the mushroom type, which has recently been put into use on the 60,000-volt transmission at Guanajuato, Mex. The top section is 14 inches in diameter. The sections are secured together with Portland cement and the whole is cemented to a hollow metal pin. For several transmissions under construction for voltages between 50,000 and 60,000, the insulator shown in Fig. 11 has been adopted. Some of these insulators exceed 14 inches in diameter and weigh as much as 25 pounds.

Abroad, insulators are used which are similar to those used in the United States. It is probable, however, that they have not been made in such large sizes, and also that corresponding sizes are used for lower voltages.

The present insulators for the highest voltages, then, of which the writer knows, and which may be considered as representing the most advanced state of the art in insulator design and construction, are represented in Figs. 8, 9, 10 and 11. Whatever advantage one may possess over the other will doubtless be shown in course of time.

Compare now the telegraph insulator, which was used as the first high-tension insulator, with these large ones. Our high-tension insulator has grown with increasing voltages from one weighing a pound or two to one weighing 25 pounds, and from 3 inches to 14 inches in diameter, and in cost from a few cents to several dollars.

We naturally begin to wonder what the future development in insulators will be. Will they continue to increase in size and in weight? If so, we can easily imagine that when an insulator 14 inches in diameter and weighing 25 pounds is required for 60,000 volts, 80,000 volts might require an insulator 20 inches in diameter and weighing 50 pounds. Further development along this line brings to our imagina-

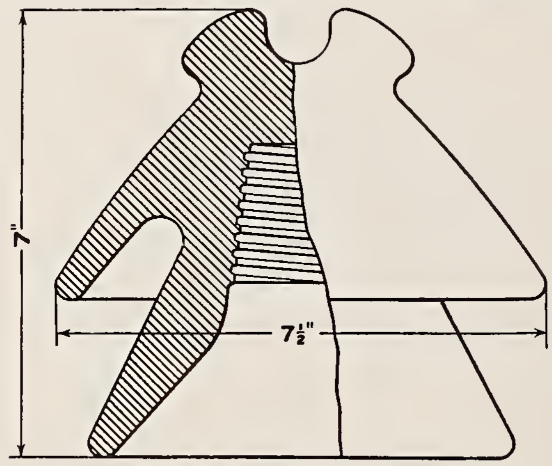


FIG. 7

tion insulators which will look not unlike Chinese pagodas and weigh perhaps several hundred pounds, as has been predicted.

This development appears ridiculous when we consider such structures made out of fragile materials like glass or porcelain, yet it is believed that much higher voltages are to be used in the future. Even now we find one company in the United States equipped in every way, except as to insulators, to transmit at 80,000 volts. We note also that the largest power development now in progress is providing to receive apparatus for 80,000 volts, the amount of power in this case being so large that it has been considered impossible to always market it within the range of territory to which it may be economically transmitted at less than 80,000 volts.

Another factor which is tending to make insulators heavier is the steel tower construction for supporting the lines. This construction means longer spans and hence heavier and stronger insulators. Some relief may be given to the insulators on these towers by housing them over to protect them from the elements. Some slight ad-

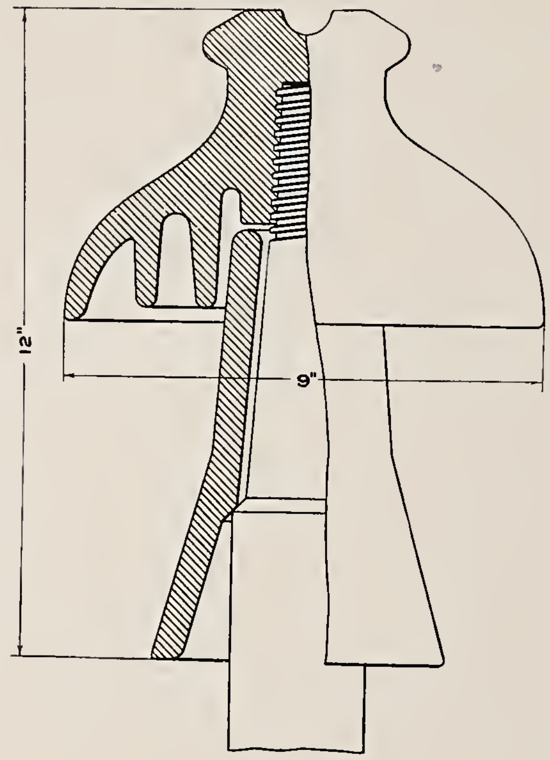


FIG. 8

vantage may also be gained by securing the wire to the under portion of the insulator, rather than on top of the insulator, as is now done.

It would seem, however, that the trend of development in high-tension transmission would continue along the lines which have become established. In favor of the further increase in voltage, it must be remembered that there is always the possibility of the discovery of some new insulating material

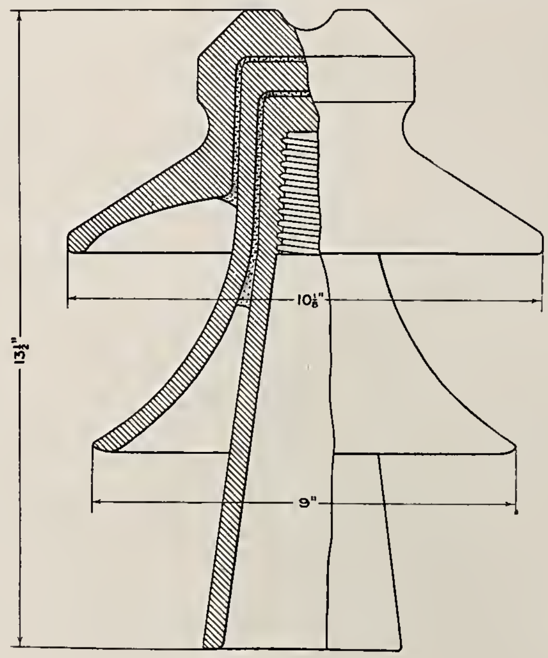


FIG. 9

which is superior to glass and porcelain; and much improvement may be expected even in glass and porcelain themselves. While a remarkable improvement has been made in the dielectric strength of porcelain, it is only

at the present day that the possibilities are beginning to be realized. Likewise with glass, we may expect a complete revolution in the method of manufacture, the art of making glass insulators having been given less thought and probably being much less

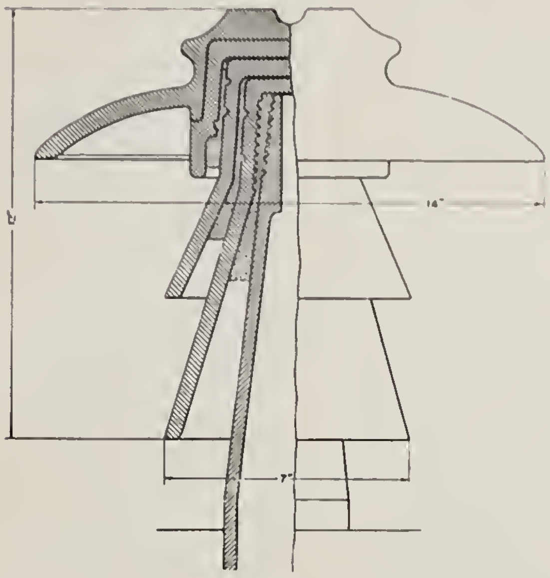


FIG. 10

advanced than the art of making porcelain insulators.

The requirements for a high-tension insulator may be enumerated as follows:—

1.—The material must have a high dielectric strength; in other words, it must be strong to resist puncture by the current. In order to fulfill this condition, the material must be continuous, compact and homogeneous, even the most minute crack or fracture being a weakness.

2.—There must be sufficient resistance over the surface of the insulator so that there will be no considerable conduction or leakage of current.

3.—The distance around the insulator between the wire and the pin or support must be sufficient to prevent the current from arcing.

4.—The second and third requirements are dependent upon the shape of the insulator. Its contour must be such that there will be unexposed surfaces which will not get wet or accumulate dirt or salt, as these materials are conducive to leakage and tend to lessen the arcing distance. Evidently the requirements which are dependent upon climatic conditions vary with the locality in which the insulators are to be used. If in a country which is not subjected to heavy rains, sleet or dust storms, the insulator may perhaps be smaller than an insulator required in a locality where the climatic conditions are severe. Usually a larger type of insulator is required for the same voltage in a cold country than in a warmer climate. This may explain why some insulators which have been very satisfactory under a given voltage in one locality have utterly failed when tried at the same voltage in another place. In some localities, particularly on the Pacific Coast, the accumulation of salt is so great from the so-called salt fogs that it has been found necessary to have the unexposed surfaces rather shallow and with few petticoats in order that the surfaces be readily accessible for periodical cleaning.

5.—The shape and arrangement of the petticoats should be such that the electrostatic capacity of the insulator will be small.

6.—The internal heat losses from conduction and hysteresis should not be such as to appreciably heat the insulator.

7.—Mechanical requirements, such as strength, mounting, method of fastening the wire, and color, are, in general, dependent upon the conditions to be met.

It does not seem as if details, like gutters, spouts, drip points, and the like, can be considered of much value. They are features which may look well in theory, but can cut but little figure in practice. Certainly the insulation of high-voltage lines is more dependent upon a good, strong insulator with liberal margins of safety, than upon such refinements.

The following tests are advised in order to determine whether insulators will meet the requirements:—

1.—In order to determine dielectric strength, porcelain insulators should be inverted, with their heads dipping into salt water, the solution extending well over the head of the insulator.

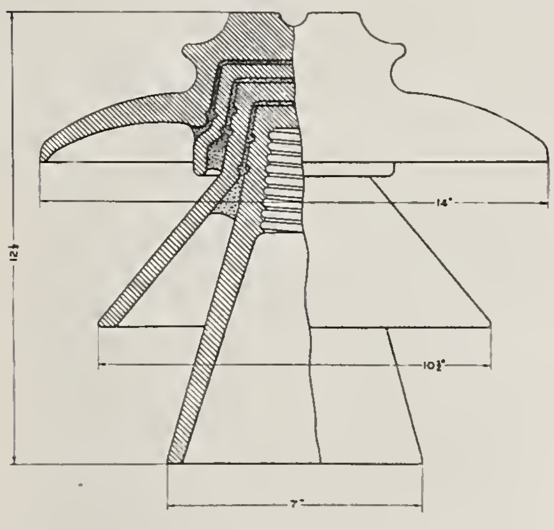


FIG. 11

The hole for the pin should also be filled with salt water. The predetermined voltage for testing may then be applied to the two salt solutions. Usually a voltage test of several minutes is made. The defective insulators will be punctured in this manner. If the porcelain insulators are made in several sections, the purpose of the sections being to obtain greater dielectric strength, then the sections should be tested individually in the same way. When the sections are cemented or assembled to complete the insulator, it is advised to again test, using the same method, in order to be certain that the sections have not been broken. Every porcelain insulator of a lot should be tested in this manner.

If the insulators are of glass, it is best to have every one tested in the manner described for porcelain insula-

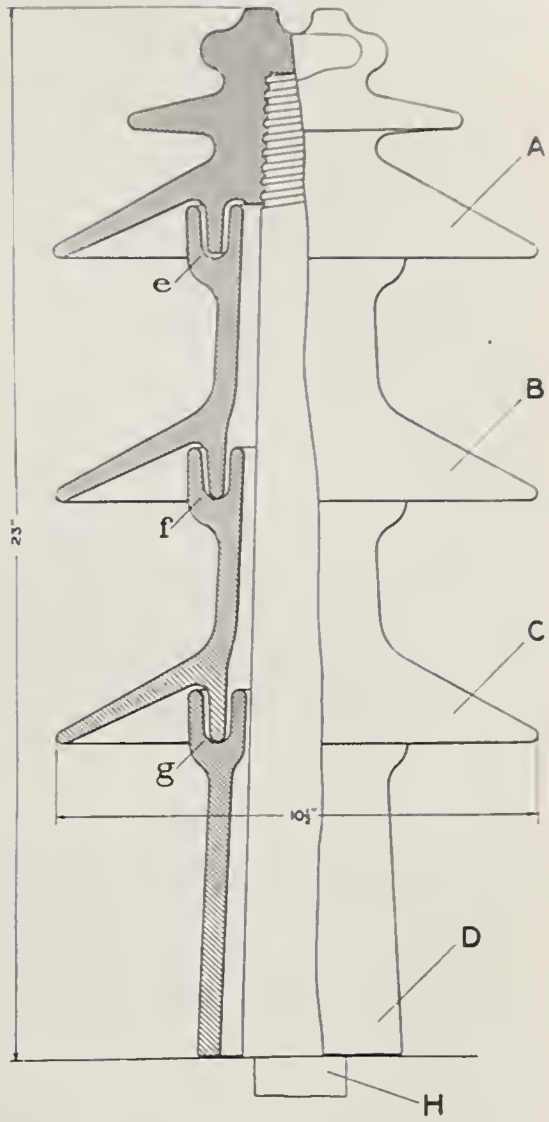


FIG. 12

tors, but as the defects in glass are easily visible, it may be necessary to test only a few of a lot in order to determine the strength of the glass, the remainder passing the rigid examination of an inspector, who will discard such insulators as have cracks, air bubbles, or less than the required thickness.

2.—The measurement of leakage over the surface of an insulator is an extremely difficult thing to accomplish, and the refined methods which are required are not applicable to factory tests of a large number of insulators. Any leakage of account will be observed in the test for dielectric strength, either by the visible creepage of the current over the surface, or by the heating of the insulator.

3.—A lot of insulators having passed a preliminary inspection, it is necessary to test only a few in order to meet the third requirement. These

ARCING AT 118 AND 157 KILOVOLTS UNDER A SPRAY OF WATER

may be set up as if in service and the predetermined voltage applied. It is customary to apply the voltage to the line and pin. It is further advised that the voltage be applied across two insulators mounted in the same way in order to duplicate as near as possible normal running conditions.

4.—In order to test for the effectiveness of the contour of an insulator, it is necessary to imitate as nearly as possible the most severe climatic conditions under which the insulator is to operate. Tests of this kind have not been extended farther than to obtain the effect of a heavy driving rain. An insulator mounted as for use should have a broken spray of water thrown upon it at an angle but slightly above the horizontal. The results of this combination may then be noted with a predetermined voltage applied between line and pin, or between two insulators similarly treated.

The value of tests should not be overestimated, for it will be recognized, especially as to dielectric resistance, that no laboratory or factory test of the dielectric strength of insulators can approach the time test of insulators in actual service. Consequently it is well to allow a wide margin of safety over the actual requirements. Wide margins of safety in every particular are also good practice in order to compensate for the abnormal voltages which are characteristic of high-tension transmissions. It is questioned whether there is any other element of a high-tension power transmission which operates on such narrow margins as the insulator. Especially is this true in America.

Unfortunately, with very high tensions, we are apparently nearing the point where the question is whether there is any margin possible, rather than how much. For a better understanding of the situation, the writer will review the conditions as he has found them.

The electrical requirements of a high-tension insulator are at variance with the requirements for mechanical strength in the following respects:—

1.—In order to increase the dielectric strength, reduce the capacity and lessen the brush discharges, it is necessary to increase the thickness of the head of the insulator. As the thickness is increased, the pin or support in the insulator is removed farther from the strains of the wire, and mechanical stresses are brought upon the insulating material which it is incapable of withstanding. Especially is this true if the wire is tied or supported on the top of the insulator.

2.—If the point of support of the wire is lowered to the side of the insulator, it is necessary that the insula-

ARCING AT 198 KILOVOLTS UNDER A SPRAY OF WATER

tor be of large diameter at the point of support in order to have the required dielectric thickness. Also with the wire on the side of the insulator, the surface distance is decreased and the length of the adjacent petticoat must be correspondingly increased.

3.—No logical or safe arrangement has ever been proposed whereby all the lines of a circuit can be supported otherwise than on the tops of the insulators. In this position the surface of the insulator is exposed to the elements, at least as far as the edge of the extending petticoat adjacent to the line, and the effect is to aggravate the cause for leakage for a certain distance, where it must be checked.

4.—The requirement for a larger insulator means one which is more breakable; if of glass, one apparently beyond the present knowledge of how to mould, or how to anneal.

The electrical requirements are also contradictory in this respect, that a larger insulator for increasing the arcing distance adds but little resistance to leakage and probably increases the capacity.

The writer early foresaw the objections to making insulators of constantly increasing diameters for increasing voltages, and proposed the making of insulators in parts and with outwardly extending petticoats. Such construction is shown in Fig. 12. Other forms of insulators embracing the essential features have already been shown, as in Figs. 9 and 11.

The purpose of the construction of the insulator shown in Fig. 12 was to study the effect of the outwardly extending petticoats in resisting arcing of the current between line and pin. The exact details of construction are a top piece, *A*, screwed onto a wooden pin, *H*; two like sections, *B* and *C*, and a supporting section, *D*, resting on the cross-arm or support, and holding *B* and *C*. *D* also serves the purpose of protecting the pin.

The grooves at *e*, *f* and *g* are for holding an insulating medium, if desirable to insulate between the several parts. These parts being readily separable, it is easy to assemble *A* and *D*, or *A*, *D*, and either *B* or *C*. Sections *A*, *B* and *C* were 10½ inches in diameter, and the whole insulator when assembled, as shown in Fig. 12, was 23 inches high from the cross-arm. Under test, the terminals of the testing apparatus being connected at the point for the wire and at the cross-arm, the current arced around at the following voltages:—

Insulator clean and dry	Kilovolts
A and D	141
A, B and D	186
A, B, C and D	225
Under a spray of water at 45 degs., precipitations ¾ inches in 5 minutes:	Kilovolts
A and D	118
A, B and D	157
A, B, C and D	198

No insulating material was used in the grooves during these tests. There was no tendency for the current to arc between the sections, and there were no serious discharges up the inside of the sections or in the grooves between the sections. This experiment is considered of importance in that the addition of each outwardly extending petticoat section requires a nearly equal additional voltage to produce arcing. The advantage of a properly proportioned insulator with outwardly extending petticoats is evidently less diameter for the same resistance to arcing around than an insulator of the mushroom type.

As to the surface conditions on insulators of glass and porcelain, no differences have been noted in the conduction or leakage of current. With high tensions, such water or moisture as falls on the insulator is quickly dispelled or dried off by the leakage of current, high tensions tending always to keep an insulator dry. In general, losses on high-tension insulators, until a brush appears, are so small that they are negligible. With the brush the losses increase very rapidly with increase in tension.

There remains for the investigator an almost unexplored field for the determination of how the potential may be distributed through an insulator; and not until such knowledge is had may we expect to know the form of the rational design, and learn of the limitations of the high-tension insulator.

THE NEW YORK CENTRAL RAILROAD COMPANY'S FIRST ELECTRIC LOCOMOTIVE ON TRIAL NEAR SCHENECTADY, N. Y.

Electric Locomotives for Steam Railroad Service

Tests Near Schenectady of the First Electric Locomotive Built for the New York Central Railroad. November 12, 1904

SOMEWHAT suggestive of the historical Rainhill contest in the year 1829 between Stephenson's locomotive "Rocket" and Ericsson's "Novelty" was an electric locomotive exhibition given last month on an experimental section of track of the New York Central Railroad near Schenectady, N. Y.

The locomotive was the first one of a lot of between thirty and fifty to be built for the above line by the General Electric Company and the American Locomotive Company, of Schenectady, and represented the beginning of what to-day is the most enterprising programme in existence for the conversion of an important section of a steam railway into an electric one. This provides for the electrical equipment of the New York terminal of the New York Central Railroad for a distance of 34 miles on the main line from New York to Croton, and for 24 miles on the Harlem Division as far as White Plains, constituting what will be known as the "Electric Traction Zone, New York District." It is the intention to handle all the traffic within this district electrically, the through passenger trains, ranging up to 875 tons in weight, to be hauled at maximum speeds of 60 to 65 miles an hour.

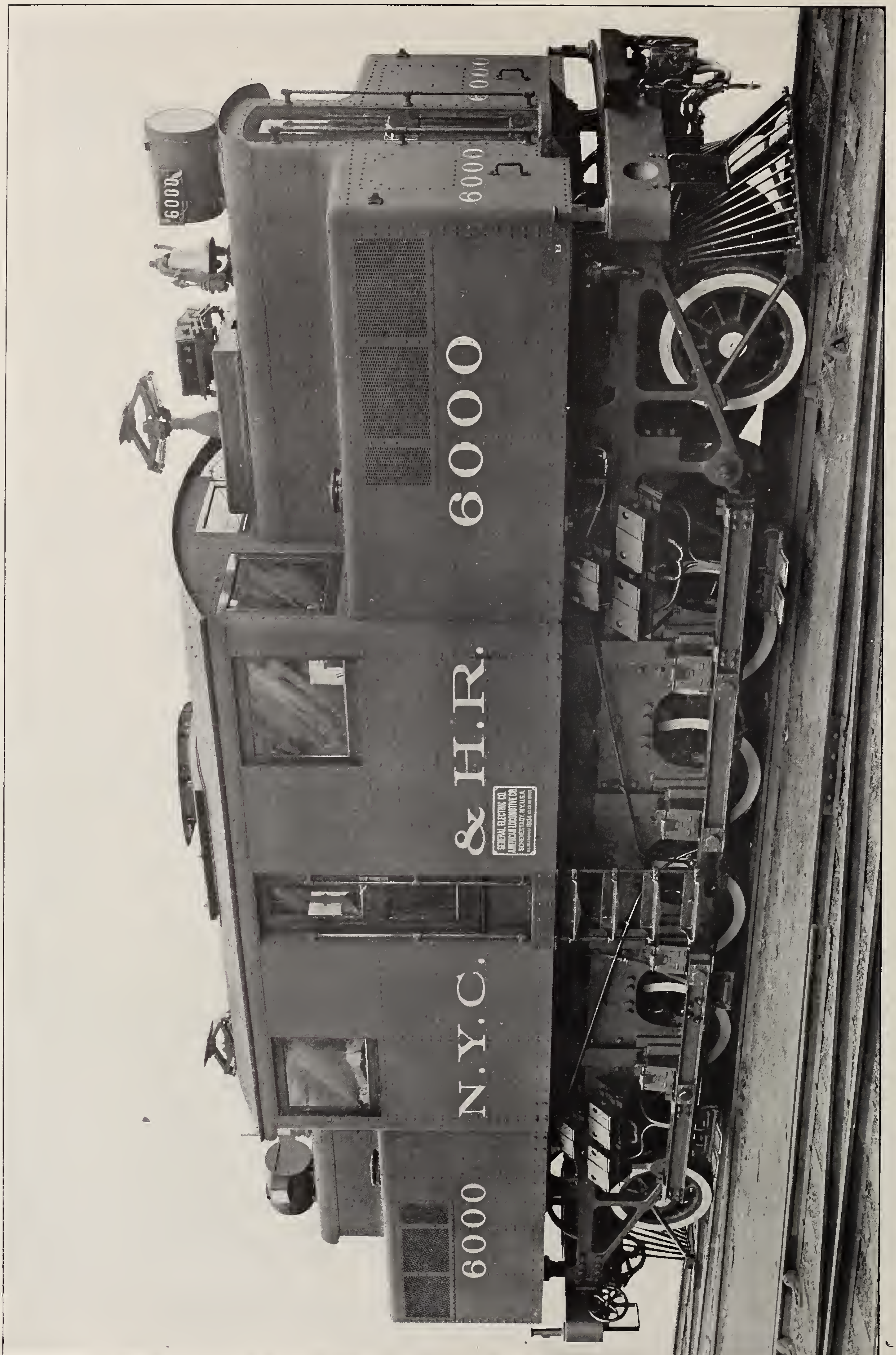
By the use of the Sprague-General Electric multiple-unit system of control, two or more locomotives can be coupled together and operated from the leading cab as a single unit. The motive power may, therefore, be easily adapted to weight of train with no complication in operation and with uniform make-up of train crew. A single electric locomotive will be able to maintain the schedule with a 450-ton train, two locomotives being coupled together for heavier trains.

The locomotive developed remarkably easy riding qualities at high speeds and during acceleration, responding with ease and power to the will of the operator.

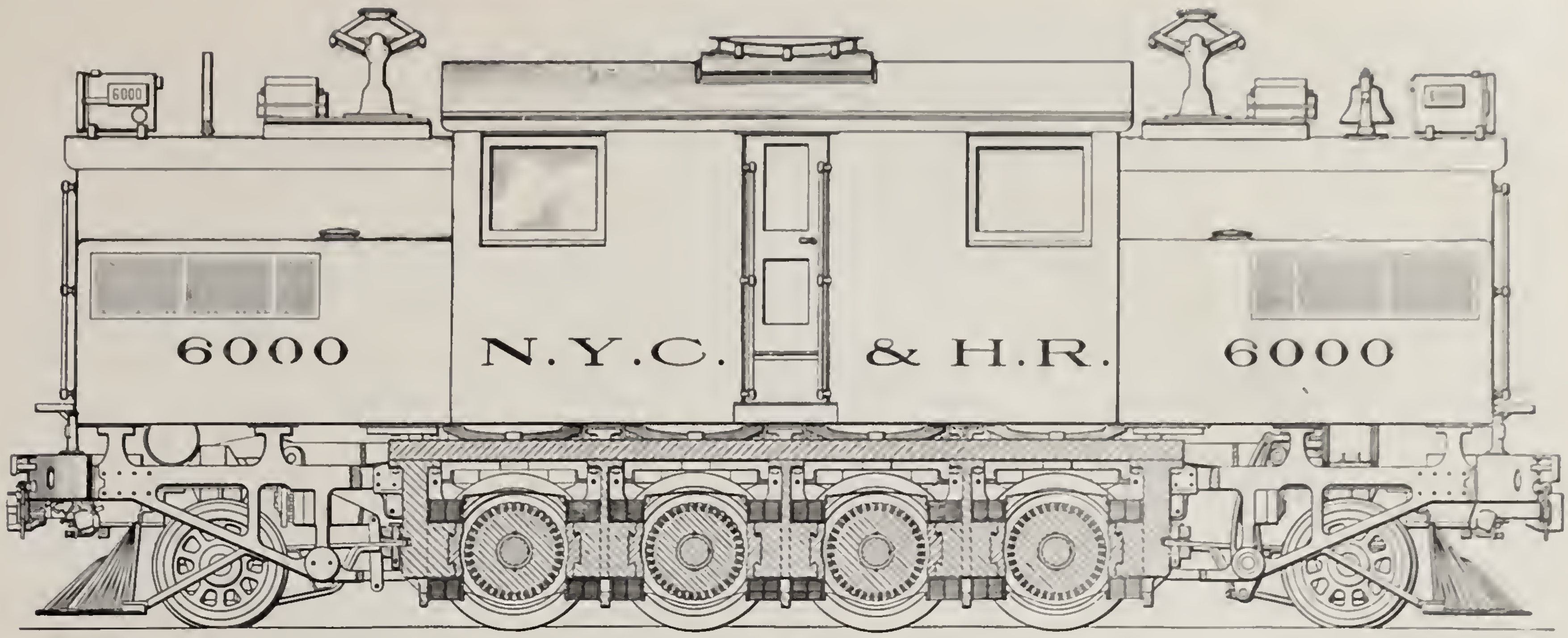
The designers have secured in this machine the best mechanical features of the high-speed steam locomotive, combined with the enormous power and simplicity in control made possible by the use of the electric drive. The success of the trials forcibly demonstrated that the steam locomotive has encountered a most formidable rival in a field of which it has heretofore held undisputed possession, and it is the general opinion that in the new locomotive has been found a type whose distinctive features may be accepted as a basis for future standardization.

The locomotive consists of four driving axles, on each of which is

THE SUB-STATION AT WYATTS, ON THE NEW YORK CENTRAL RAILROAD COMPANY'S EXPERIMENTAL LINE NEAR SCHENECTADY, N. Y. POWER IS SUPPLIED TO THE STATION FROM THE GENERAL ELECTRIC COMPANY'S WORKS FIVE MILES AWAY. THE THIRD RAIL AND ALSO THE OVERHEAD SPECIAL WORK AT A ROAD CROSSING ARE HERE CLEARLY SHOWN



THE FIRST ELECTRIC LOCOMOTIVE BUILT FOR NEW YORK TERMINAL SERVICE ON THE LINES OF THE NEW YORK CENTRAL RAILROAD



A SIDE ELEVATION OF THE LOCOMOTIVE AND LONGITUDINAL SECTION THROUGH THE FRAME

mounted, without intermediate gearing, the armature of an electric motor having a normal rating of 550 H. P. The total rated capacity of the locomotive is thus 2200 H. P., although for short periods a considerably greater power may be developed, making it more powerful than the largest steam locomotive in existence.

Hitherto gearless locomotives have been built with the armature of the electric motors mounted on quills and springs suspended from the driving wheels. In the new locomotive the use of spring-suspended quills is dispensed with, the armature being mounted rigidly upon the axle, thus reducing the bearings to those of the pony trucks and the main journals, all of which are outside of the driving wheels. The motor has two poles with flat faces, so as to permit a large relative vertical movement between armature and poles as the latter move up and down with the riding of the frame upon the springs.

A longitudinal section of the locomotive frame is shown in Fig. 1. The main frame is of cast steel, and forms not only the mechanical frame of the locomotive, but also part of the magnetic circuit of the electric motors. It will be seen that the armatures are arranged in tandem, the end pole pieces being cast as part of the end frames, and the double pole pieces between the armatures being carried by heavy steel transoms bolted to the side frame and forming part of the magnetic circuit, as well as cross braces for the truck. The field coils are wound upon metal spools, which are bolted upon the pole pieces. Proper distribution and division of the weight of the locomotive amongst the axles has been accomplished by suspending the main frame and superstructure from a system of half elliptic springs and equalized levers of forged steel, the whole being so arranged as to cross-equalize the load and to furnish three points of support.

This construction, besides being strong and simple in design, greatly facilitates repairs and renewals, as an armature with its wheels and axle may be removed by lowering the complete element without disturbing the fields or any other part of the locomotive, and a new element inserted in its place. All parts are also especially accessible for inspection and cleaning.

The pony trucks are of the radial type, and are pivoted by means of radius bars to the end frame of the main truck. The frame of the locomotive immediately above the trucks is supported by means of suitable links, so that the truck is free to swing about its center and is self-centering on a straight track. This design is similar to the standard construction adopted by the New York Central & Hudson River Railroad Company for its steam locomotives.

The brush holders are mounted on insulated supports attached to the spring saddle over the axle journal, thus maintaining a fixed position of the brush holder in relation to the commutator. These brush holders are made adjustable so as to allow for wear of the commutator and journal bearings.

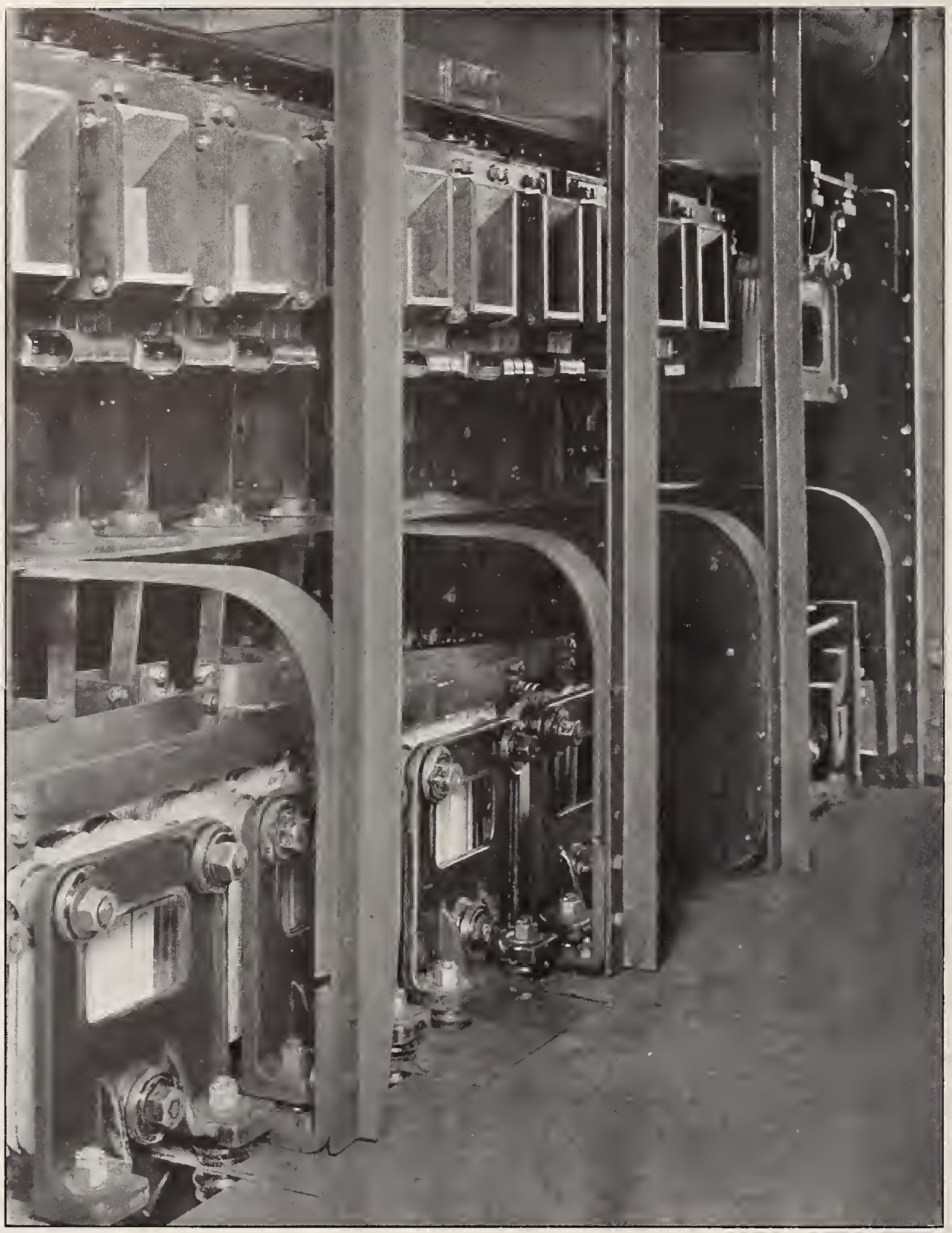
The dead weight on the axle is not materially greater than is customary with steam locomotives, and in addition there is no unbalanced weight to produce vibration with attendant injuries to track and roadbed construction. The actual reduction in the expense of maintaining the rails and roadbed, due to the absence of pounding and rolling, will have an important bearing on the up-keep of the permanent way.

The superstructure consists of a central cab for the operator, containing master controllers, engineer's valves and switches and valves required for operating sanding, whistling and bell-ringing devices. This apparatus is furnished in duplicate, one set on each side of the cab, and is arranged so as to be easily manipulated from the operator's seat, while at the same time a practically unobstructed view to front and rear may be obtained from the windows. The air gauge, meters, etc., are located so as to be easily read by the driver.

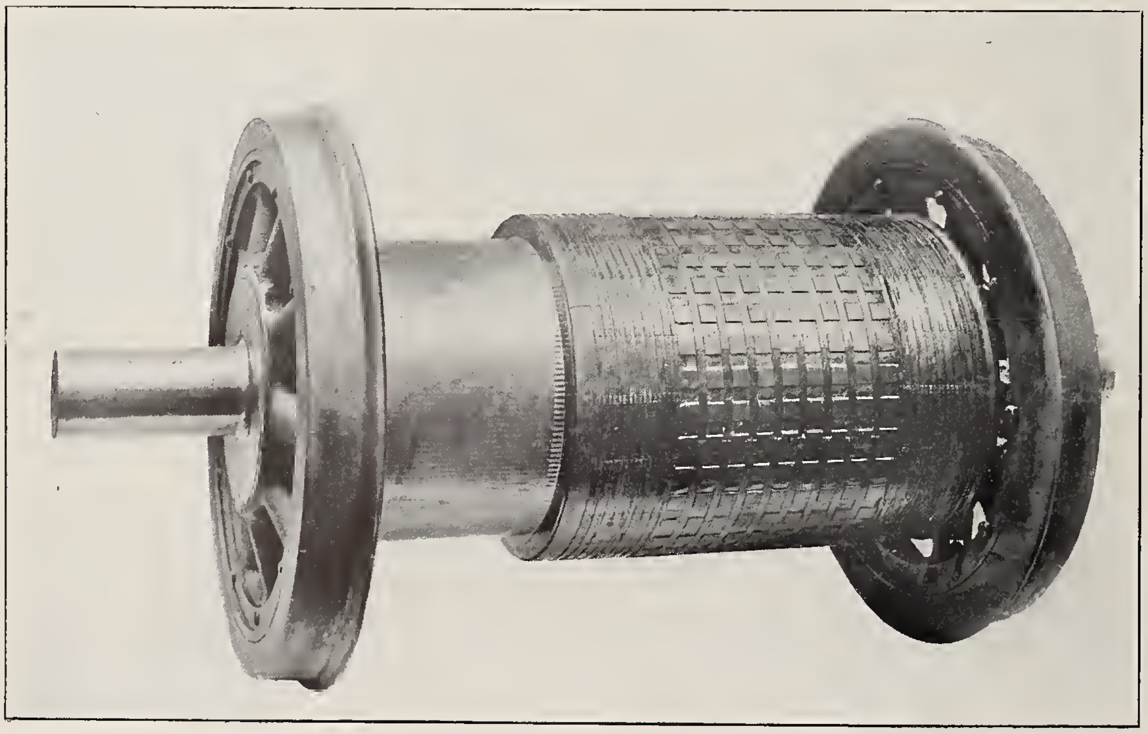
There is a central corridor extending through the cab so as to permit access from the locomotive to the cars behind, and the contactors, rheostats and reversers are arranged along the sides of these corridors, in boxes of sheet steel, which are sheathed on the inside with fireproof insulating material. All of these appliances are, therefore, easily accessible for repairs or inspection.

THE AMPERE RIBBON FUSE-BOX

The control system permits three running connections, namely, four motors in series, two groups of two in parallel series, and all four motors in parallel. The motor reverser, con-



CONTACTORS AND RHEOSTATS AT ONE END OF THE LOCOMOTIVE CAB



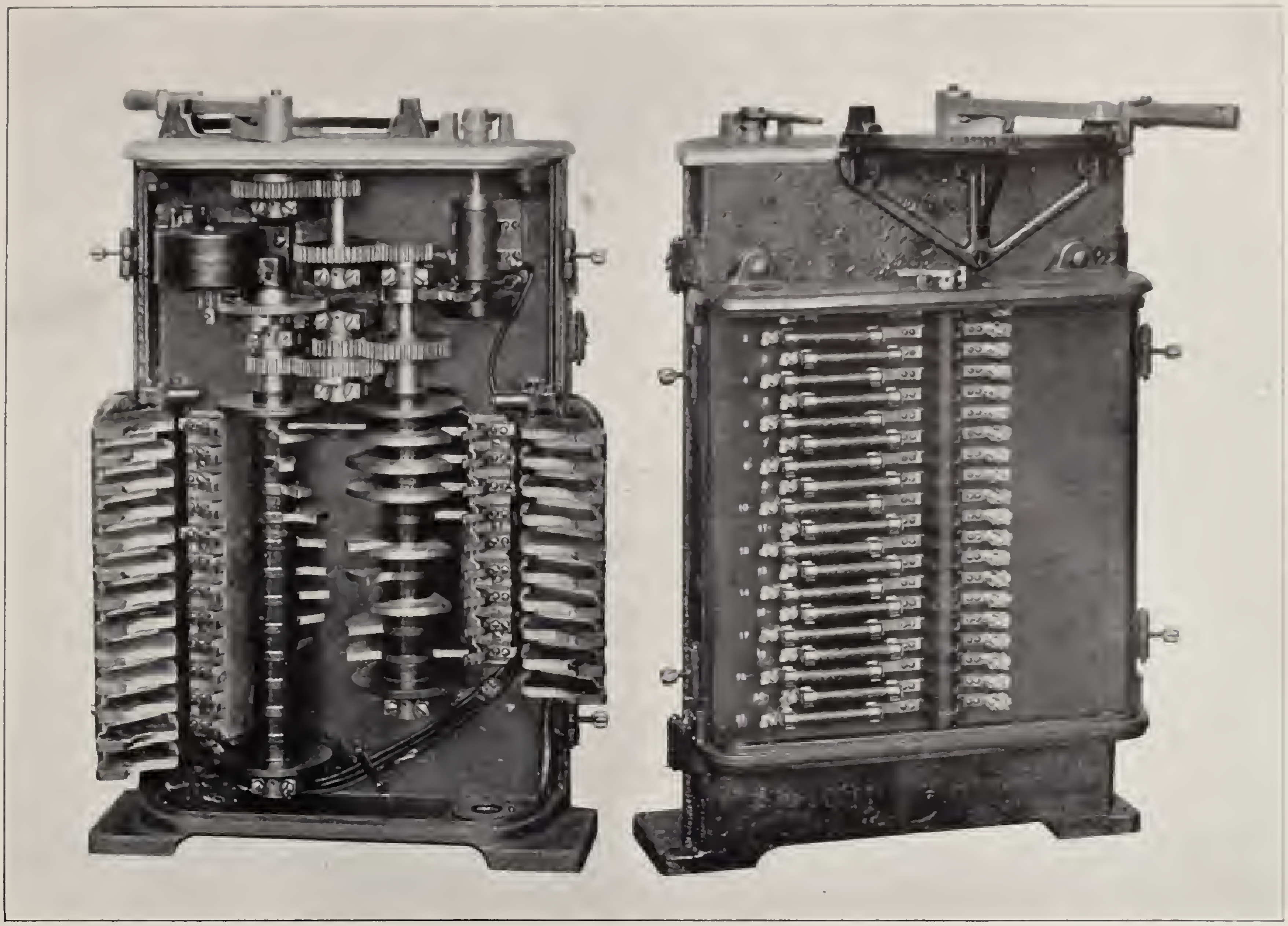
ONE OF THE ARMATURES IN PLACE

tactors, rheostats and other controlling appliances are all of the Sprague-General Electric multiple-unit type. The master controller, however, is fitted with a special operating lever about 24 inches long and capable of being moved through an angle of about 75 degrees. A current-limiting device is provided in the master controller, and consists of a friction clutch operated by an electric magnet, which is energized by the current passing through one of the motors, the arrangement being such that when the current exceeds a predetermined amount the cylinder cannot be rotated further until the current has fallen sufficiently to allow the relay to drop. As long as the current does not exceed the desired limit the automatic feature is not in operation.

In the operator's cab there is placed a General Electric motor-driven air compressor having a capacity of 75 cubic feet of free air per minute, and consisting of a twin vertical-cylinder compressor driven by two 600-volt direct-current series motors. The compressor is controlled by a governor, which automatically cuts the motors in and out of circuit when the air pressure falls below 125 pounds or rises about 135 pounds. A reduction in air pressure sufficient to actuate any governor simultaneously starts up the air compressors in both locomotives when running double-headed, and likewise when the air pressure has been raised and any one air compressure is closed down, the other will be cut out of service.

Current is collected from the third rail by multiple-contact spring actuated third-rail shoes, whose supports are carried on channel irons attached to the journal box. There are four of these shoes on each side of the locomotive. In the yards at the terminal the large number of switches and crossings necessitates an overhead construction in places, and additional contacts are therefore mounted on the top of the locomotive for collecting current when the locomotive is passing over these points. This device may be raised and lowered by air pressure controlled from the engineer's cab. A magnetic ribbon fuse is placed in circuit with each shoe and overhead contact device so as to secure protection in case of accidental short circuit.

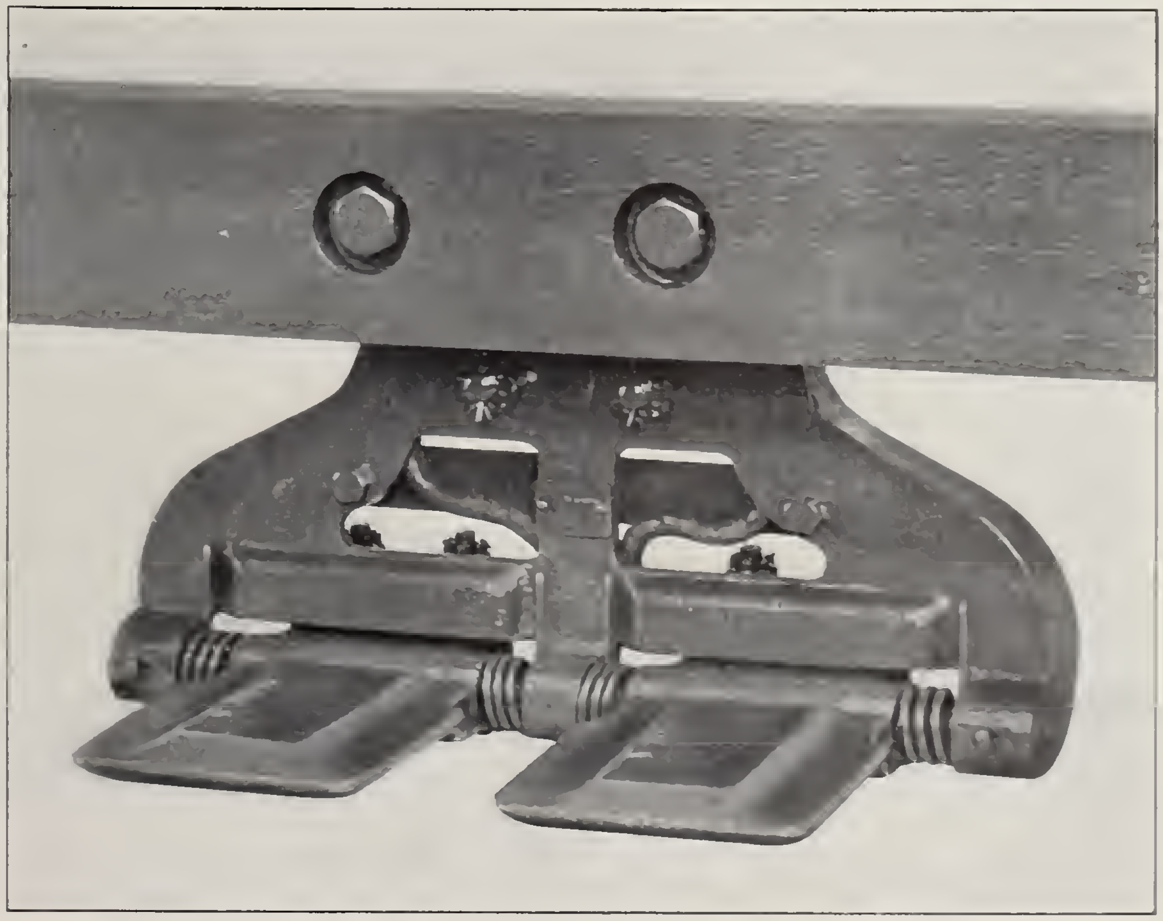
It is the intention of the New York Central & Hudson River Railroad Company and the General Electric Company to make complete preliminary tests and trials on these locomotives under all conditions likely to obtain in service operation. For this purpose the New York Central &



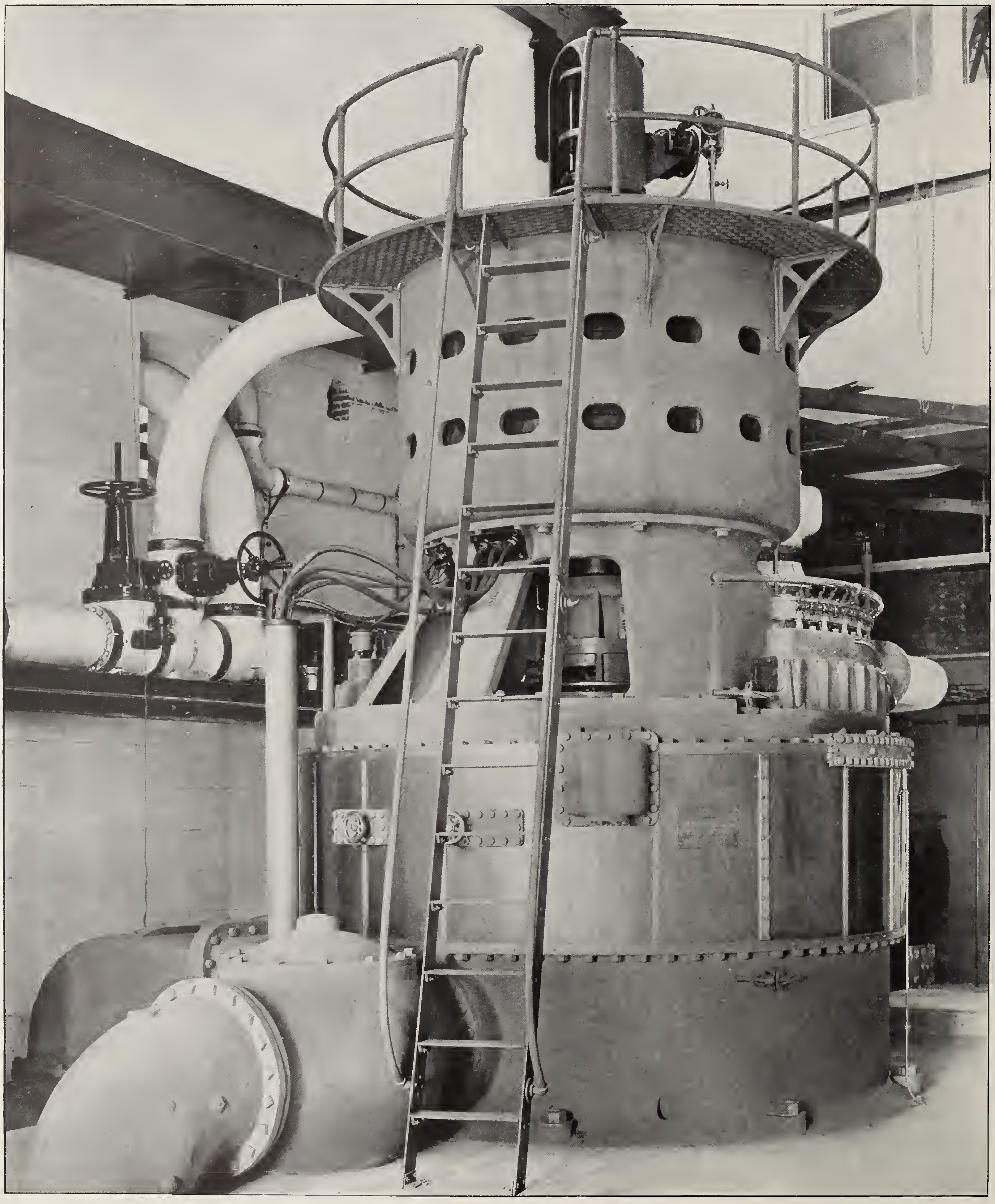
FRONT AND REAR VIEWS OF THE MASTER CONTROLLER, SHOWING CUT-OUT SWITCH

Hudson River Railroad Company has set aside a six-mile stretch of track on its main line between Schenectady and Hoffmans, and has equipped it with standard third-rail construction. The track is practically straight and ballasted so as to permit a maximum speed of 70 to 80 miles per hour being attained.

Power for operating the locomotive is furnished by the General Electric Company, and for this purpose there has been installed in the new power house at the Schenectady plant a 2000-K. W., three-phase, 25-cycle Curtis turbo-generator, delivering 11,000-volt current to a special high-tension transmission line, which has been constructed from the power station for a distance of 5 miles to the sub-station at Wyatts. This sub-station, shown on pages 441 and 448, contains a 1500-K. W., 650-volt, 25-cycle General Electric rotary converter, with necessary static transformers for reducing the line potential from 11,000 to 460 volts, and a switchboard consisting of a 600-volt direct-current rotary converter panel,



ONE OF THE CURRENT-COLLECTING SHOE SETS



THE 2000-K. W. CURTIS TURBINE GENERATOR SUPPLYING CURRENT FOR THE EXPERIMENTAL LINE NEAR SCHENECTADY. THIS IS LOCATED AT THE WORKS OF THE GENERAL ELECTRIC COMPANY

PRELIMINARY SPEED RUN NO. I.—EIGHT-CAR TRAIN, 336 TONS; LOCOMOTIVE, 95 TONS; TOTAL, 431 TONS. DIAMETER OF DRIVERS, 44 INCHES

an alternating-current starting panel and a high-tension panel with an electrically operated oil switch. The rotary converter is self-starting from the alternating-current end, thus requiring no synchronizing or other complications when throwing the machine into service. The step-down transformers are provided with taps giving 1-3, 2-3 and full voltage for starting the rotary converter, these voltages being applied successively by means of double-throw lever switches. The machine starts freely and easily without sparking and without drawing more than full load current from the line.

The apparatus in the sub-station, its location and arrangement, and its dimensions are, in general, as proposed for the sub-stations to be built within the electric zone at the New York City terminal of the railroad company, so that practical experience with the plant may be obtained while the locomotive tests are being made and in advance of construction.

This power station, transmission line, sub-station equipment and 6 miles of track are, undoubtedly, the most complete testing plant ever provided for trial of electric railroad motive power, and with the facilities afforded in addition to testing the new locomotives much interesting and valuable electric railroad information will unquestionably be obtained.

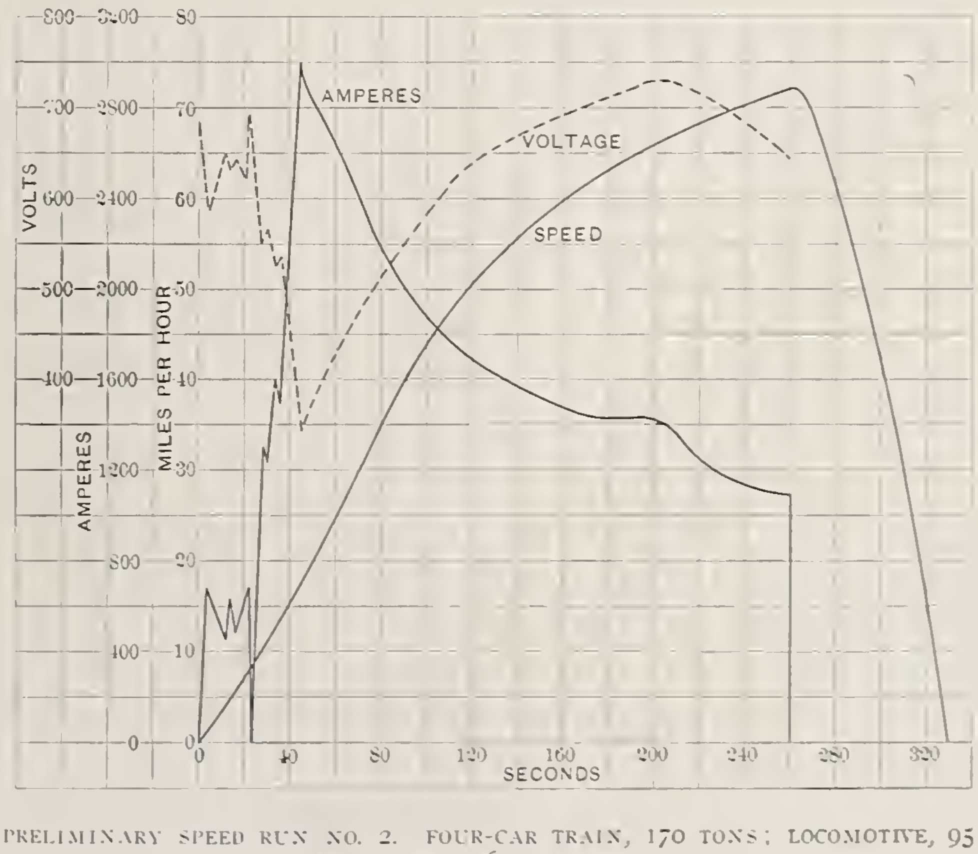
The general dimensions and data applying to the locomotive are as follows:—

Number of driving wheels	8
Number of pony trucks	2
Total weight of locomotive	95 tons
Weight on drivers	69 tons
Rigid wheel base	13 feet
Total wheel base	27 feet
Length over buffer platforms	37 feet
Extreme width	10 feet
Height to top of cab	14 feet 4 inches
Diameter of drivers	44 inches
Diameter of pony truck wheels	36 inches
Diameter of driving axles	8.5 inches
Normal rated horse-power of locomotives	2200
Maximum horse-power	3000
Normal draw-bar pull	20,400 lbs.
Maximum starting draw-bar pull	32,000 lbs.
Speed with 500-ton train	60 m. p. h.
Voltage of current supply	600
Normal full-load current	3050 amperes
Maximum full-load current	4300 amperes
Number of motors	4
Type of motor	GE-84-A
Rating of each motor	550 H. P.

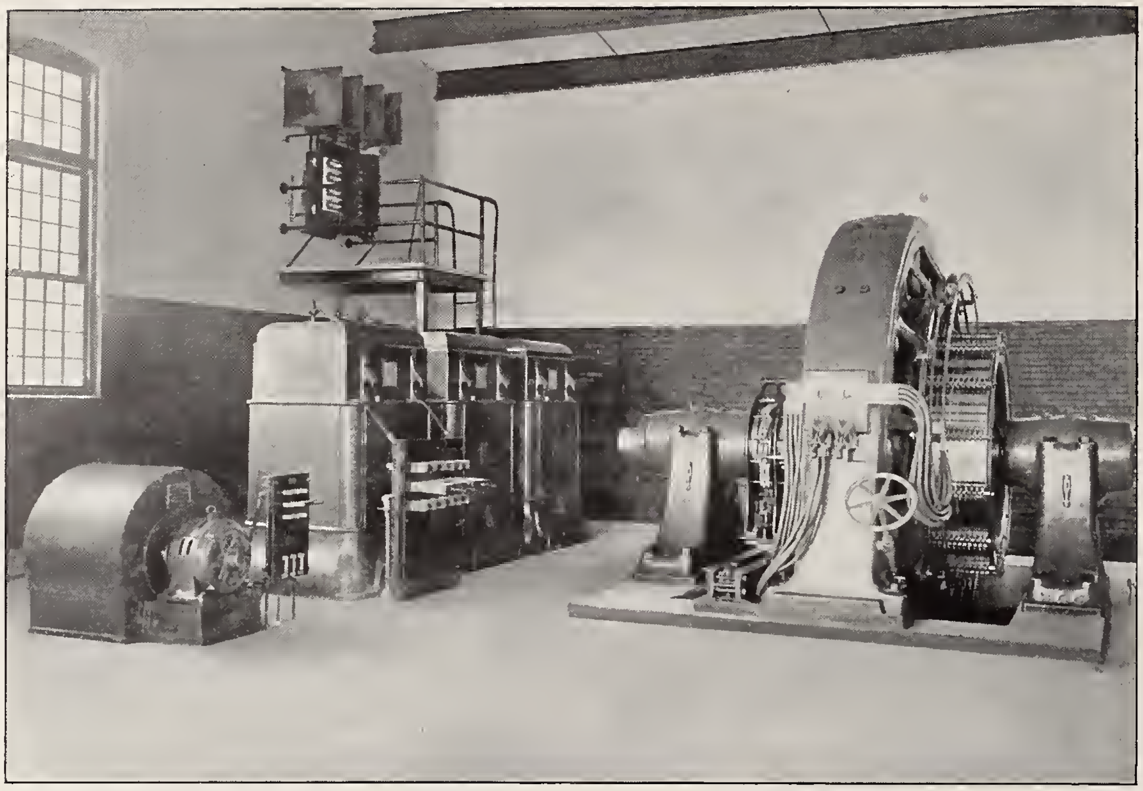
Owing to the fact that only a portion of the track to be used for testing is thus far available, no complete locomotive tests have been made. A full set of recording instruments has been installed in the cab, and records have been obtained of some of the preliminary runs made to test the bearings and running qualities of the locomotive. Although these records will be superseded by careful tests made on the full length of track, bonded with sufficient feeders supplied to minimize the drop, they indicate in a general way what may be expected of the locomotive running in regular service. Curve sheets are shown on this page and page 448, giving speed, current input and voltage at the locomotive, all on a time basis, with an eight-car train weighing 336 tons and a four-car train weighing 170 tons, both exclusive of locomotive. The total weight of train, including locomotive and passengers, was 431 tons, and 265 tons for the eight-car and four-car trains, respectively.

Two sets of curves are shown, two running tests reaching as high a maximum speed as possible with the length of track available, and two sets of starting tests showing the more rapid rate of acceleration possible with the higher maintained voltage available near the sub-station. The maximum speeds reached were 63 miles per hour with an eight-car train and 72 miles per hour with a four-car train. It will be noted that the trains were still accelerating at these speeds, but the length of track so far equipped did not permit attaining higher speeds. The New York Central locomotives are not designed for abnormally high speeds at intervals, but rather to obtain a high average schedule, due to their ability to accelerate more rapidly than is possible with the present steam locomotives.

In the starting tests a speed of 30 miles per hour was reached in 60 seconds with an eight-car train weighing,



PRELIMINARY SPEED RUN NO. 2. FOUR-CAR TRAIN, 170 TONS; LOCOMOTIVE, 95 TONS; TOTAL, 265 TONS



THE SUB-STATION AT WYATTS CONTAINS A 1500-K. W. ROTARY CONVERTER, AIR BLAST TRANSFORMERS AND SWITCHING APPARATUS

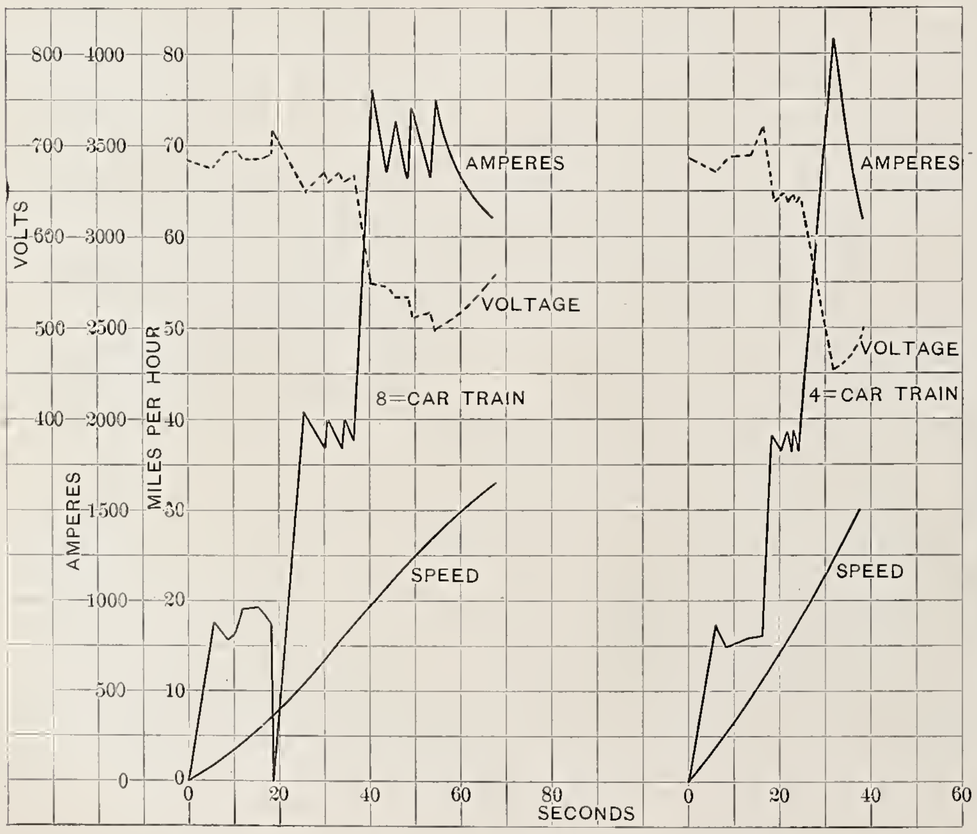
including the locomotive, 431 tons, corresponding to an acceleration of half a mile per hour per second. During certain periods of acceleration the increase in speed amounted to 0.6 miles per hour per second, calling for a tractive effort of approximately 27,000 pounds developed at the rim of the locomotive drivers. This value was somewhat exceeded with the four-car train, where a momentary input of 4200 amperes developed a tractive effort of 31,000 pounds at the drivers with a coefficient of traction of 22.5 per cent. of weight on drivers.

The average rate of acceleration with the four-car train, weighing, including the locomotive, 265 tons, was 30 miles in $37\frac{1}{2}$ seconds, or 0.8 miles per hour per second, calling for an average tractive effort of 22,000 pounds.

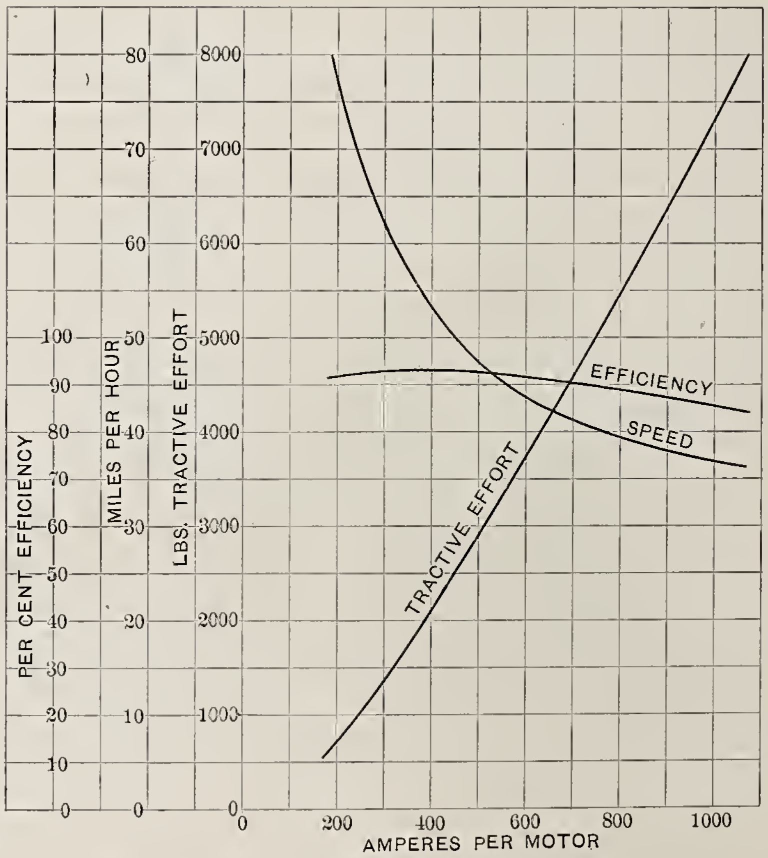
The maximum input recorded, 4200 amperes at 460 volts, or 1935 K. W., gives an output of the motors of 2200 H. P. available at the wheel. With 4200 amperes and a maintained potential of 600 volts there would have been an input to the locomotive of 2500 K. W., corresponding to 2870-H. P. output of the motors. This output is secured without in any way exceeding the safe commutation limit of the motors and with a coefficient of traction of only 22.5 per cent. of the weight upon the drivers, thus placing this electric locomotive in advance of any steam locomotive yet built. No service capacity temperature runs have been made as yet, and the preliminary tests have not shown any appreciable warming up of the motors sufficiently to take thermometer readings.

Throughout both the starting and running tests the electric locomotive shows its remarkable steadiness in running, a distinct contrast in this respect to the steam locomotive, especially should the latter be forced to perform the work here shown to be accomplished by the electric locomotive.

The elimination of gear and bearing losses permits of a very high efficiency of the locomotive. Reference to the motor characteristics shows a maximum efficiency of approximately 93 per cent., this value being fully 4 per cent. better than possible with motors of the geared type. This gain is especially noticeable at the high speeds, the efficiency curve remaining above 90 per cent., even at the free running speed of the locomotive alone, in contrast to the 85 per cent. or less which would be a good showing for a locomotive provided with geared motors. The simple construction and high efficiency made possible with this design of gearless motor, together with the minimum cost of repairs attending such a construction, makes the direct-current gearless motor type of loco-



STARTING-TEST CURVES FOR EIGHT AND FOUR-CAR TRAINS IN EXPERIMENTAL RUNS



CHARACTERISTIC CURVES OF SPEED, EFFICIENCY AND TRACTIVE EFFORT

motive a distinct forward step in electric locomotive construction.

The power houses for the "electric zone" of the New York Central Railroad are now under construction, one on the banks of the Hudson River near Glenwood and the other near Port Morris. Each power station will be cross-connected to the several sub-stations. It is the intention to have everything ready for operation in the latter part of 1906.

Electricity and Physics

Discussed Before the New York Electrical Society

At a meeting of the New York Electrical Society, held in the hall of the American Institute, on November 30, 1904, Professor William Hallock gave a highly interesting lecture on "Electricity and Physics."

Professor Hallock premised his remarks by drawing attention to the fact that, in the general understanding of the term, physics deals with the single atom, while chemistry relates to the operations of the molecules of matter by which intimate bodies are changed or acquire new properties. Again, outside of the realm of chemistry, physics treats of the nature and properties of bodies, the phenomena and the laws that govern them.

Mechanics, on the other hand, treats of the laws of motion and has to do with the forces by which bodies are kept in equilibrium or in motion. In the broad sense, said the speaker, when the mechanics of the ether are better understood, all sciences would ultimately be classed under the head of mechanics; and sound, heat, light, electricity, chemistry, etc., would then be treated as branches of mechanics.

Professor Hallock then discoursed upon the electron, the cathode and Roentgen rays, and radium, explaining in lucid language, among other things, the manner in which is proven the view that the electrons are electrically charged particles, namely, by the deflection of the rays in a modified Crookes tube, by magnetism and by means of positively and negatively charged plates in the tube, the negative rays being invariably deflected toward the positively charged plate and away from the negatively charged one.

The probable reason why the Roentgen rays and the negative electrons were less readily absorbed by air or metal than the positive electrons, was explained on the supposition that the Roentgen rays are simply disturbances of the ether (due to the impact of the ions against a solid body), and by the relative dimensions of the negative and positive electrons, the smaller particles passing more freely than the larger ones through the given space between the particles of the solid substance, the fact that the absorption of the rays is roughly proportional to the density of the solid body lending support to this view.

In closing, Professor Hallock recommended those of his hearers whose interest in this fascinating subject might have been excited by his necessarily hasty outline, to procure some of the published works on the subject, such as those by Soddy and by Rutherford. He said that no one need be deterred from a study of this subject by the fear that it would be found too abstruse for ordinary students, the subject in the hands of these noted workers in this new field being treated in the simplest language. This is a view that was also expressed in a review of Rutherford's book "Radio Activity" in the July number of this journal. Incidentally, it may be noted that the subject is also concisely and clearly treated in a section devoted to the electronic theory in "Maver's Wireless Telegraphy."

In the discussion that followed the lecture, it seemed to be difficult for some of the speakers to grasp the idea of a particle consisting only of a "charge" that is assumed to be massless, or how a massless charge can possess inertia, overlooking the fact, perhaps, that electrical induction or inertia is not related to mass in the ordinary sense.

Further, in this relation it may be remarked that since on the electronic theory the electrons are assumed to possess the property of inertia, and inasmuch as on this theory the material atoms are agregations of electrons, the exponents of this theory suggest that mechanical inertia is explainable on the basis of electrical inertia or inductance.

The lecture closed with stereopticon views of some of the foremost workers in the domain of electricity and radioactivity, after which a vote of thanks was tendered to the lecturer.

A church at Sherburne, N. Y., has installed a telephone system connecting a special transmitter at the pulpit with the pews of the deaf members of the congregation.

Book News

An Engineering Student's Notes

By J. Richards. Published by the Industrial Publishing Company, San Francisco, Cal. 291 pages.

The matter contained in this little book appeared originally in "Industry," between the years 1890 and 1897. It is described by the author as "technical, philosophical and otherwise," and consists of notes taken by a technical student on a journey with his uncle through the United States, Great Britain and Europe.

The technical part of the book is made up of descriptions of the engineering features on board ship, in machine shops and factories. The book has an anecdotal side, and the uncle, a marine engineer, is responsible for the greater part of the philosophy. There is nothing that will not be understood by a non-technical reader, while the technical reader will find not a little to interest him.

The Art of Wise Investing

Published by the Moody Publishing Company, New York; 89 pages. Price, $1.00.

A series of three short articles on investment values are contained in this booklet, "pointing out the essential characteristics of safe investment securities, with a review of the financial pitfalls into which superficial examination inevitably leads."

The preface states that ten times as much money is lost annually in the United States through unwise investment as through pure speculation. The first article points out the danger of relying solely on brokers' advice, and describes some of the common errors made by investors taking things for granted. The methods used to catch the gullible public are described and rules are given for the guidance of the investor and to help him differentiate between a good and a bad investment.

The second article tells of the real purpose of the stock exchange and its inner workings, and exposes the methods of dishonest brokers for fleecing "lambs." The last article describes how the industrial growth of the country and the change from sole ownership or partnership to a corporation has made necessary a means of placing before the public accurate details and statistics of many thousand public corporations, a means found in the development of the Bureau of Corporation Statistics of New York, organized by Mr. John Moody in 1900.

The 22,000 H. P. electric plant of Lyons is one of the largest in Europe.

THE ELECTRICAL AGE

Volume XXXIII Number 6
$2.50 a year; 25 cents a copy

New York, December, 1904

Entered at the P. O. as 2d-class matter. Copyright, Louis Cassier

ESTABLISHED 1883

Published monthly at 3, 5 and 7 W. 29th Street, New York City.
Telephone No. 1617 and 1618 Madison Square. Private branch exchange connecting all departments. Cable Address—Cassier, New York.

SUBSCRIPTION RATES

The Electrical Age will be sent post free anywhere in the United States and its possessions, Canada and Mexico for $2.50 per year, single copies 25 cents. To Great Britain and all countries embraced in the postal union, $3.75, 15 shillings, 19 francs, 15 marks, or 10 rupees. Send subscriptions to our nearest branch office or agency.

NOTICE TO ADVERTISERS

Insertion of new advertisements or changes of copy cannot be guaranteed for the following issue if received later than the 15th of each month.

LONDON OFFICES

Business Department, 33, Bedford Street. Editorial Department, 22, Henrietta Street. Covent Garden, Strand, W. C.

London Telephone, Post Office, 3807 Central. Private branch exchange. London Cable Address – Revolvable, London.
All remittances to London Office should be crossed London and County Banking Company.

BRANCH OFFICES AND AGENCIES

Subscriptions may be sent to the following branch office or agencies, where they will receive the same careful attention as at the home office in New York:

124, Queen St., Melbourne
359, George St., Sydney
61, Main St., Yokohama
23, Esplanade Rd., Bombay
33, Loop St., Cape Town
Unter den Linden, 5, Berlin
Nevsky Prospect, St. Petersburg
31, bis rue de Fauburg Montmartre, Paris

General Agents for United States and Canada: The American News Company

Leading Articles

Electricity in Sea Coast Defense. By M. C. Sullivan ... 401
Eras in Electrical Development. By Charles F. Scott ... 407
A Thomson-Houston Coterie of 1893. By Dugald M. McKillop ... 409
Smoke Prevention. By R. S. Hale ... 411
Electric Traction on Steam Railways. By Alton D. Adams ... 417
Electricity in Textile Mills. By Charles Robbins ... 428
The Increasing Use of the Telephone. By H. S. Webb ... 431
High-Tension Insulators. By V. G. Converse. 434
Electric Locomotives for Steam Railroad Service. By a Staff Correspondent ... 440
The Chicago-St. Louis Wireless Telegraph Tests ... 450
The Induction Motor in the Carpet Mill ... 450
Freight Carriage by Trolley Lines ... 451
The Telephone in the Recent Election ... 452
Electricity in the Twentieth Century. By Howard S. Knowlton ... 454
The Electric Motor for Speed Regulation. By Dr. Schuyler S. Wheeler ... 459
Electrical Energy Direct from Coal. By J. Wright ... 476

The Chicago-St. Louis Wireless Telegraph Tests

A FULL account of the results of the long-distance wireless telegraph tests between St. Louis and Chicago, and of the interesting precautions taken to insure against deception, has been published. To avoid any possibility of collusion on the part of any of those concerned in the tests, the message to be transmitted was made out in duplicate and placed in sealed envelopes, one of which was taken to Chicago, the other being left in St. Louis. Upon a given signal, the envelope at St. Louis was opened and given to the operator for transmission.

The message comprised thirty-four words made up of two hundred and five letters, and consisted mainly of the names of men prominent in the discovery and development of wireless telegraphy. The message took three minutes in transmission, which is at the rate of 11 1-3 words a minute, or, allowing five letters to a word, a rate of 13 1-3 words a minute. This, it will be observed, is very much below the rate of transmission claimed for the system employed in these tests, namely, the De Forest, but it is safe to assume that a desire to insure strict accuracy kept the operators down to a lower speed than otherwise would be necessary.

Besides the sending of a regular message, extracts from a book were sent by direction of the jury and were correctly received. The question was considered by the jury as to whether it would be feasible to pick up the messages by wireless telegraphy in a suburb of St. Louis, and thence by means of a telegraph repeater to transmit the message to a suburb of Chicago where another telegraph repeater would transmit it by wireless to the Chicago station. It was decided that, even assuming there had been opportunity to put such an arrangement into effect, the messages could not have been transmitted by this means in anything like the time actually consumed in the sending of the messages.

We do not for a moment assume that any deception of this kind was considered by those making the test, but if the jury is correctly reported as saying that the messages could not be automatically repeated in the manner described, in the time stated, it shows a blissful ignorance of everyday telegraph practice. In other words, to all intents and purposes, a message repeated in such a manner and transmitted at the rate of ten words a minute, would arrive at its destination practically as though it had been transmitted without repetition.

A further test which eliminated the operators from either end of the circuit was made. In this test, one of the jury in St. Louis was asked to make the letter "d," a dash and two dots, repeatedly. This letter was heard by members of the jury in Chicago when the telephone receiver was held to the ear. Apparently, there was not a practical telegrapher on the jury. Possibly it was thought that, inasmuch as this was a wireless telegraph test, a telegrapherless jury was in order.

In our issue of October, in commenting on this long-distance wireless test, we directed attention to the possibility of the overhead wires and railroad tracks between the cities in question having something to do with the propagation of the electric waves set up in the transmission of the messages. At that time we were not aware that a long-distance telephone metallic circuit was within almost touching distance of the wireless apparatus at both stations, for the exclusive use of the jury during the tests. In view of this fact, and especially when the exceeding sensitiveness of the electrolytic detector used in this system, and the high power of the transmitter, are considered, the question naturally arises as to whether these tests may not simply have constituted a repetition on a large scale of the Hertz and Lodge experiments on the propagation of waves on wires. On this view, which seems plausible, it might be advisable for the jury to attempt to decide whether any award given, as a result of these experiments, should be for improvements in wire or wireless telegraphy.

The Induction Motor in the Carpet Mill

THE advantages of the electric motor for driving all sorts of manufacturing machinery are probably better appreciated to-day than at any previous time. It is well, however, that a warning against hasty and indiscriminate work of this kind

has recently been sounded by Messrs. Day, Dunn and other engineers who are closely identified with advanced practice in the reconstruction of existing factories and the application of motors to both belted and direct-coupled machines. There is no doubt that the financial results of a change to motor driving may easily be unsatisfactory if the work is carried out on the basis of snap judgment decisions. Thus, the problem of using direct or alternating current motors is frequently one open to wide differences of opinion.

Probably the majority of motor-driven manufacturing plants thus far installed have been rightly equipped with direct-current machines. The distance of transmission is generally short enough—if the power plant is centrally located—to offer no very considerable advantage in the way of copper economy in favor of using alternating current; the speed control of the older machine has been worked out upon a reasonably satisfactory basis; and finally, the satisfactory experience of thousands of motor users has militated against the adoption of the less familiar alternating types. Then, too, the first cost has been brought down by the manufacture of standard direct-current machines in large quantities, and the previous equipment of many shops with a direct-current lighting plant has been a strong argument against adopting mixed apparatus at the time of changing over from the old shafting methods to the motor-drive.

In some classes of work, however, the alternating current motor exhibits a remarkable adaptability to the conditions. Examples of successful cotton mill practice, for instance, are scattered through the Southern States; instances of the further advance of the alternating motor may be multiplied in the mining regions of the west; and in New England the isolated plant and the factory are both beginning to appreciate the unique advantages of the induction motor in particular. Thus, in the Dwinell & Wright wholesale coffee roasting house in Boston, induction motors have been installed to operate the coffee and spice mills, elevators, roasters, etc.; the Union Metallic Cartridge Co., of Bridgeport, Conn., is about to install an alternating plant, and the Whittall Carpet Mills, in Worcester, have recently completed an interesting induction motor drive for the complicated looms, spinning frames, cards, speeders, washing machines, extractors, and ventilating fans common to the carpet industry.

In the Whittall plant there are at present twenty-five induction motors of the three-phase type, varying in size from the 2-horse power machines used to operate the dye-house ventilating fans and the economizer scrapers in the power house to the 75-H.P. motors which drive the groups of line shafting in the various mills. The load on the plant aggregates about 600-K. W., with a lighting load of about 2000 sixteen-candle-power incandescent lamps. One 800-K. W., 40-cycle 600-volt direct-connected generator supplies all the current for the mills, and the entire installation bears the mark of careful design and construction.

The load is generally uniform, except when the mills throw on and off their different machines at morning, noon and night. This enables the induction motors to handle the work of the mills without noticeably disturbing the lights by the lagging current in starting or taking on additional load. The freedom with which the motors may be started and stopped gives a flexibility of operation to the plant which would not be possible with synchronous motors, and the simplicity of the construction augurs well for depreciation and maintenance account.

Perhaps the most striking advantage of the induction motor in the carpet mill is its safety as regards employees and its freedom from fire risk. With no exposed contacts, and with carefully wired power leads and controlling boxes, there is almost no danger of accident through any employee's casually coming in contact with the electrical equipment. The relatively high voltage used on the motors enabled the saving of an amount of copper decidedly worth while, in comparison with the ordinary 220-volt shop distribution.

The absence of the commutator which is, and probably always will be, the bugbear of direct-current dynamos and motors constitutes in this case a termendous advantage over the latter type of machinery, and cuts down the possibility of fire to its lowest degree. No spark from an induction motor is likely to be set free to ignite the fluffy yarns and wools which abound on the premises of a carpet mill. It is difficult to weigh this decreased fire risk on any financial scale, but it is a point well worth considering in shops and factories where direct-current machinery competes with alternating for contract award. Repairs, too, are a simple matter with the induction motor when the rare occasions arise for their accomplishment.

It would be a mistake to conclude that the induction motor is the key to every difficult problem in machine driving because it has been applied with such signal success to a growing number of installations where the matter of speed-control is not the vital consideration of the situaton. These plants are yet few enough to warrant the careful study, on the part of their operators, of the cost of running, fixed charges, life of equipment, possibility of increased output, etc. It lies within the power of the owners of installations like the Whittall plant to do excellent service to the engineering profession by making the results of operation public at some appropriate future time.

Experience is worth as much as a guide to correct engineering as it is of value in any other walk of life, and it is a work of the broadest good will for an operating company to give others the benefit of its experience when it has had the courage to break away from so-called standard practice and pay the cost of adopting new methods. Of course, the induction motor is a tried and trusted piece of apparatus, but it is certain that the financial results of its application to mill driving are still worth determining and discussing.

Freight Carriage by Trolley Lines

FREIGHT transportation on railroads, including the transmission of mail and express packages, represents a part of the work of suburban and interurban lines which has received rather tardy recognition from the electrical point of view, but now that the passenger service of trolleys and trunk lines has developed so satisfactorily, the freight department is likely to receive more attention. In attempting to enter the field of common freight carriers, trolley lines have encountered innumerable difficulties, not the least of which is simply a prejudice existing in some States against them as such carriers. Indeed, the charters of many of the New England trolley lines expressly forbid them to undertake freight transportation. The fear that the freight service might tend to congest the road so that the passenger service would be hampered, has induced many legislators to deny the applications for trolley road charters that included the right to carry freight, express matter, and the mails, especially where the roads entered into direct competition with existing steam roads.

As the commercial prosperity and development of many sections of the suburbs depend upon quick and frequent freight, mail and express delivery, it is evident that the trolley roads must become common freight carriers in time, and that both the

steam roads and the express and mail wagons must yield some of their rights to the electric cars. The volume of freight traffic increases rapidly with the progress of civilization, and it assumes in bulk proportions that make city congestion a pressing problem.

The lately finished freight tunnel of Chicago seeks to solve it in that city, and when that tunnel is completely equipped with cars and other electrical accessories, the street traffic congestion of freight will be greatly reduced. In New York both surface and elevated electric railways have entered into the freight and mail traffic business, while the recently completed subway will tend to eliminate even more of the street traffic troubles by carrying a portion of the mail and express matter. So far as large cities are concerned, the electrical railroads have made considerable progress in freight carrying, and their development must be continuous and rapid. Conditions demand this, and old-time prejudice cannot place insurmountable obstacles in the way.

But the suburban and interurban freight traffic service offers somewhat different phases of the subject. Every improvement that increases the rapid and frequent delivery of goods on railroad lines has a corresponding good effect upon the passenger service. Fast and frequent mails, as well as prompt delivery of freight and express matter, stimulate the growth of suburban towns and villages. A road that is up-to-date appreciates this so thoroughly that the freight department often absorbs the highest talent of the company. Naturally, the freight trolley service that interferes with passenger traffic is not popular with the public, and the modern electrical management must therefore find methods of transporting freight without such interference.

The suburban electrical freight service entering New York has been developed to a point of efficiency that shows the possibilities in this direction. Owing to the fact that the passenger traffic is most difficult to handle only during the rush hours of morning and evening, the management of these suburban trolley lines run most of the freight and express cars in the middle of the day when the minimum of interference with the passenger service is caused.

But important as the freight trolley line between the suburbs and the cities is in distributing mail and express packages, it is more directly efficient and beneficial in bringing the farmer and country producer in close contact with the markets. The handling of perishable fruit and vegetables is a considerable item in the freight service of many roads. The suburban trolley that carries freight makes frequent runs through the rural districts to the cities, and as a result market gardeners are beginning to ship their produce to the markets in this way.

In the vicinity of Boston many tons of farm produce are shipped to the city every day during the growing season, and these perishable goods are thus delivered to the consumers within a short time after harvesting. The effect has been that the market gardens have increased in number along the freight-carrying trolley lines. Frequent service and stopping points are the chief virtues of the trolley line both for passengers as well as freight. The farmer thus is supplied with increased and improved facilities for getting his goods to market. Instead of driving several miles to a railroad station, and after much delay finding his trip too late for the last train, he carries his produce to some convenient point on the line of the trolley where he can have it loaded for immediate delivery.

The experiences which the market gardeners in the vicinity of Boston have met are almost duplicated near Philadelphia, Brooklyn, and other large cities which enjoy good trolley systems both for freight and passenger service. The demands upon the market gardeners have in recent years increased in proportion to the growth of the cities, and the higher prices of land have forced them to take up land further from the market centers. The old market and truck wagons have thus had longer journeys to make. The price of land near the cities has, in many instances, made it impossible for the truck gardeners to make good profits, in spite of their intensive methods of farming. It thus seemed for a long time as if the nearby market gardener would be forced out of existence, while the southern truck farms could ship their goods by steamer to the coast cities at prices which made them formidable competitors in the northern markets.

The suburban freight trolley roads are rapidly changing these conditions. The goods are being shipped so continuously and quickly by trolley service that produce seldom has a chance to wilt or decay on the way. It is possible even to harvest market garden products early in the morning and have them delivered to consumers on the same day. In the suburbs of Brooklyn a good many gardeners have their city consumers whom they supply with fresh strawberries, lettuce, and sweet corn and peas in the season by trolley express service, so that often less than ten hours elapse between harvesting and consumption.

Handling of low-class freight has not been generally attempted by trolley lines, for this involves expensive terminals. The established steam railroads can do this much cheaper and better. Such service would demand numerous switching places, both at the terminals and along the line of the route where freight is delivered. But the higher class freight, such as express packages, and even the mails, forms legitimate material for the trolley roads. This class of freight requires quick and efficient handling and delivery. Owing to the wide ramification of the trolley lines in a city, the electric roads have superior equipments for transporting high-class freight and express packages than the steam roads. There are few points of a city to which the express and freight cars do not run, and the final delivery by wagon or automobiles is simple. The time saved by this method forms an important part of the whole subject under consideration.

So far the trolley freight and express roads have not entered into competition with the steam railroads by cutting rates. As this is generally ruinous to both parties, the effort has been made to build up the new service without resorting to rate wars. But with fewer terminal facilities and expensive buildings to keep up, the trolleys would be in a better position to make profits on their freight and express service than the steam roads, and in the event of a rate war they would probably suffer the least.

The Telephone in the Recent Election

THE successful part which the telephone now plays in the rapid transmission of news was never more strikingly illustrated than in the recent national election. Besides allowing the candidates of the two prominent parties to be in daily communication with their respective campaign committees, the telephone transmitted the returns to all the newspapers in the larger cities and to other subscribers, such as campaign committees, clubs, and the like.

In New York City this necessitated the keeping of all the operating forces with a large number of reliefs, all aggregating about 1000. At one exchange alone the election service required 215 employees. As fast as the returns came in, they were edited, and typewritten bulletins were made in manifold and then given to operators seated at a long table, who transmitted the information to the subscribers. It was estimated that 10,000 calls were

received and replies sent at the particular exchange in question and about four times that number at the others.

In Chicago an arrangement was successfully tried of grouping 10 transmitters and extending to each a rubber tube from one mouthpiece. To each transmitter 20 lines were connected, so that one operator was able to read the returns to 200 subscribers simultaneously. The method of receiving, revising and preparing the bulletins for the readers was substantially the same as in the New York exchanges.

Overland Wireless Telegraphy

IN a letter to the Editor, under date of December 3, 1904, Mr. Reginald A. Fessenden, of the National Electric Signaling Company, of Washington, D. C., writes:—

"Your very interesting editorials on wireless telegraphy* have been called to my attention, and I am fortunately able to supply information in regard to some of the points you mention.

"In connection with the Schenectady-Lynn transmission of 185 miles, I would say that in acceptig this contract we are not endeavoring to go a longer distance than we have already found to be commercially operative, as we have for nearly a year been working between Washington and Philadelphia, which distance is nearly as great as that between Lynn and Schenectady, and have also worked between New York and Washington direct, which distance is considerably greater. As the heights of the antennæ used at these latter stations are only 132½ and 135 feet, respectively, and the power is only about ¼ H. P., while the masts at Schenectady-Lynn are 175 feet high and we shall use at least 1 H. P., it will be seen that the Lynn-Schenectady transmission does not involve anything new so far as distance is concerned.

"With reference to the other inquiry made, i. e., why, although our New York-Philadelphia stations have been operating for more than a year and our Philadelphia-Washington stations for nearly a year, we have never taken commercial messages, in spite of the fact that these lines are used regularly as means of communication between our New York and Washington offices, I would say that the reason is a very simple one, having no connection with the operation of the stations, and is as follows:—

"After we had been working our New York-Philadelphia stations for two months, we decided to go in for commercial work and arranged to open up offices in New York and Philadelphia. On making an estimate of the receipts which could be expected, two new points came up:—

"First.—There is very little profit to be made from running a single line between two large cities, as only about 500 messages can be handled per day of ten hours. Consequently, a multiplex system is needed to get good financial results.

"Second.—We found that there was a practical certainty that during certain times of the day the messages would come in faster than a single line could handle the business, and consequently either the messages would be delayed or else we would have to send the overflow by the Western Union and Postal Telegraph lines. If the messages were held, it would be said that the wireless lines were not reliable and did not give good service. If we sent the overflow messages by the wire lines, this fact would soon become known publicly and the statement would be made that the whole business was a fraud.

"In view of these facts we decided that it was inadvisable at present to take commercial work between these points until we had perfected our multiplex apparatus.

"I would say that at the present time the multiplex apparatus is in fairly good shape and is now capable of transmitting twelve messages simultaneously. We are, therefore, now in a position to go ahead with commercial work, but there are some other lines which our company desires to develop first, so that when we go into the commercial field we can do so on a large scale.

"In connection with this matter, I would say that during the last storm the National Electric Signaling Company offered the use of its wireless stations to the Postal and Western Union Telegraph lines for handling messages between Washington and New York, Washington and Philadelphia and Washington and Annapolis, which offer was not, however, accepted. But a considerable amount of private business was carried on during this time.

"It is obvious that the above commercial considerations do not apply to cases where a single line can handle the business, and consequently this company has been taking contracts for a number of private lines, such as the General Electric line, and also for a number of commercial lines. One of these latter lines is a duplex relay line, 1000 miles long, which is to take the place of two cables whose yearly gross receipts have been approximately a quarter of a million dollars."

[It is gratifying to notice that we have from a gentleman of Mr. Fessenden's large experience in wireless telegraphy so complete a confirmation of the statement in the October number of this journal, that "at best, the amount that a wireless circuit or two, in the present state of the art, will add to the existing overland wire facilities, is but a drop in the bucket." The statement that his system is now capable of transmitting twelve messages simultaneously is very interesting, but the immediately following remark is disappointing, namely, that his company desires to developfirst some other lines before going into the commercial field on a large scale. This method is not the one that has usually been followed in wire telegraphy, but there are numerous precedents for it in wireless telegraphy. For example, it has frequently been implied in the public and technical press that long before now we should have had trans-Atlantic wireless telegraphy, but for the fact that the inventor was busy with preparations for more extensive signaling distances. Might it not also be suggested that possibly the New York-Philadelphia circuit, if ready for operation, would gladly be leased by some of the many important private users of the telegraph between those cities? If we do not misunderstand Mr. Fessenden's remark relative to the installation of a duplex relay wireless line to take the place of two cables, it is difficult to appreciate what is to be gained thereby—in other words, why displace two cables that are earning a quarter of a million dollars annually?
—THE EDITOR.]

* Printed in THE ELECTRICAL AGE for October and November, 1904.

Electric Heating Apparatus at the St. Louis Exposition

REFERRING to the article last month, entitled "Cooking with Electricity," the American Electrical Heater Company, of Detroit, Mich., writes to the effect that the Electrical Restaurant at the St. Louis Exposition, there mentioned, was equipped entirely with electric heating appliances of their make, and that to avoid possible misinterpretation of the author's remarks, this fact should have been stated. Publicity is cheerfully given to it here, with the added information that the above company turn out a complete line of electric heating appliances,—soldering irons, for example, laundry irons, glue pots, and the like, besides electric cooking apparatus.

Electricity in the Twentieth Century

By HOWARD S. KNOWLTON

ALMOST everyone living to-day in a civilized community realizes that electricity plays an important part in the affairs of life, but few persons outside the world of engineering have an adequate conception of the extent to which this wonderful form of energy is being utilized for the benefit of mankind. We meet with the telephone, telegraph, arc light, incandescent lamp and electric car in every important center of population, and these common appliances have become as familiar as if they had been part and parcel of our ancestors' material existence.

The progress of applied science has been so rapid that we have almost lost the power of being surprised at its new discoveries and applications. As a result of thus taking things for granted, we overlook both the short period of time in which the growth of practical electricity has taken place and the magnitude of its development.

Seventeen years ago a convention of street railway men, meeting in the United States, condemned the discussion of electric motive power for city traction as a waste of time, and devoted the remainder of their session to problems connected with the stabling and feeding of horses and mules. In 1903 the electric railways of the United States carried about three times the population of the earth as passengers, and to-day 55,000 electric cars speed along the streets of American cities, some of them operating in systems which carry a million passengers every twenty-four hours. At the time of the convention referred to, there were probably not over 100 trolley cars in this country, and the success of these had not been universally recognized. The car of that period was a bob-tailed affair with little resemblance to the 48-ton interurban car of to-day. It was run by a single motor of 10 H. P. To-day a 600 to 800-H. P. equipment is used for heavy service.

The telephone itself is not yet a generation old, having first been made known to the public at the time of the Centennial Exposition at Philadelphia in 1876. Even fifteen years ago the city exchange represented the maximum development springing from the invention of this electric appliance. Long-distance conversations were almost unknown, and the recent daily service between Boston, Mass., and Omaha, Neb., over a line about 1500 miles in length, was scarcely imagined. The apparatus of that day bears little resemblance to the equipment of modern central offices in appearance, compactness, flexibility and economy of operation. The Colorado ranchman and the Massachusetts farmer to-day rent telephones in every way as powerful, for long-distance conversation, as those of the New York banker. Salt Lake City will probably talk to Portland, Me., within the next two or three years.

Thirty years ago the world's submarine telegraph system comprised about 47,000 miles of ocean cables, many of which were unworkable. Fifteen words per minute were the maximum speed of transmission. This "nervous system of civilization" has extended to over a quarter of a million miles of submarine cable line, all of which is working, while the speed has advanced to over 47 words a minute in each direction by the latest trans-Atlantic connection. Land telegraphy has also multiplied in extent in the United States from about 175,000 miles of wire in 1874 to nearly a million and a half miles, exclusive of railroad telegraph lines.

It is thus an easy task to show that electrical progress has been made at an astounding rate within the last quarter of a century. The phenomena of electricity have advanced from the curiosities of science to the importance of principles determining the welfare of humanity, and from apparatus which used to be the toys of speculative philosophers has been evolved the commercial electrical machinery of modern life.

If Gilbert and Franklin could return to this world, we can imagine their surprise and bewilderment upon being confronted with the achievements of their illustrious followers in the domain of electricity, not to mention steam. We would lay the morning papers at their plates, filled with news from far-off Korea—news sent silently under the sea. Franklin, perhaps, would be less incredulous than his companion philosopher, for the thought of transmitting electric signals was an idea not entirely foreign to his mind. If we should tell Dr. Gilbert, however, that the death of Queen Victoria was posted upon the bulletin boards of the Boston newspapers within twenty minutes of its occurrence, he would certainly shake his head and think we were making game of him.

A ride in an electric elevated train, added to a telephone chat with Chicago, and a visit to one or two electric power plants would convince both of our distinguished guests that their successors had attained an undreamed-of mastery of the forces of nature and had acquired tools and instruments of investigation more powerful and more delicate than the world has ever before seen.

To record in detail the variety of applications of electricity in modern life one would be obliged to describe industrial, social and domestic activities over the entire civilized world. We can scarcely imagine the plight we would be in if this form of energy should be annihilated. Electricity not only carries us from place to place in swift, comfortable cars—it also warns us of overheated homes, calls the police, outruns the criminal, turns night into day, decorates our ball rooms and expositions, heats curling irons, soldering irons and hot-water bottles, sets in motion a hundred firemen and a score of horses at the crooking of a finger, carries the peculiar personal qualities of our voices across half a continent and drives an almost infinite variety of machinery in our shops and factories.

It may be generated by the power of falling water, wind, and the combustion of coal, wood or oil, transformed from currents generated at pressures that would not harm an infant to waves of energy as dangerous to human life as the lightning bolt and, subdivided, led about and distributed through endless intricacies of conducting circuits with the docility of a trained servant. It runs from the front door to the rear of the house with the pressing of a button, carries swift tidings of life and death across the ocean in a second, and in wireless waves conveys the greeting of a president to a king.

The contrast between small and great things is most striking in elec-

trical science. In the telephone receiver we have an instrument so delicate that a sound is produced by far less than a hundred millionth of the current required to operate an ordinary 16-candle-power lamp, while another instrument—the "totalizing" ammeter of an electric railway plant—will measure current enough to operate over a quarter of a million such lamps. Induction coils may be wound with wire so fine that 6 miles of it weigh less than a pound and, on the other hand, the same length of the largest street railway cable may weigh 120 tons, or nearly a quarter of a million times as much. In electrical manufacturing, we may find in one establishment workmen engaged in microscopic polishing and fitting of delicate jewel bearings to electric meter mechanisms, while others direct the movements of huge dynamo castings weighing many tons. The factories themselves may be run by the transmitted power of a waterfall 100 miles away.

One would believe the whole earth had been ransacked for materials after looking over the list of substances required in electrical construction. Copper, iron, lead, zinc, calcium, carbon, cotton, silk, mica, cellulose, platinum, pasteboard, glass, porcelain, quartz, wood, jute, hemp, paper, rubber, aluminium and innumerable other products of nature constitute the raw material of electrical apparatus. Enormous quantities of these substances are used yearly by the manufacturers.

Applicable as electricity is to almost every art and handicraft, the study of its utilization constantly finds fresh and fascinating material before it. The field is so vast that few men ever see its whole extent. Even the specialist, whose business it is to keep up with electrical progress through the work of the technical journalist, finds it almost impossible to avoid falling behind at times in some particular field. Every new undertaking conceived and carried out on a large scale always brings with it conditions and problems different from those encountered in any previous work. For this reason most electrical engineers are obliged to confine their practice to a limited range of activities. That is to say, one may devote his life to rapid transit problems, another to long-distance power transmission, a third to electrochemistry, and so on.

In the great manufacturing establishments the organization of the work has been carried to such a pitch that a man may spend all his days in the design of one particular type of machine and still be constantly occupied with new propositions, to say nothing of the workman in the machine shop, whose life is passed in carrying out a single operation among the hundreds which change the raw material into the finished product.

Among the more recent triumphs of applied electricity, the adaptation of the small motor to the driving of all sorts of machinery challenges the admiration of every inquiring mind. The range of this branch of electrical science is well nigh limitless. The small motor drives the fans which ventilate the home, office and public buildings; it operates printing presses, coffee grinders, sewing machines, lathes, dental engines, advertising mechanisms, candy pullers, machine tools of every description, meat choppers, cash-carrier systems, looms, pumps, pill machines—in short, there is almost no form of mechanism which the electric motor is incapable of driving.

Experience with this form of power in printing has demonstrated beyond question the superiority of the electric drive. The dangers of belts are eliminated; the amount of work which can be done in a given time is increased through the absence of injury by lint and dirt; and last, but not least in importance, the speed may be easily varied to suit the requirements of different kinds of type, ink and paper. In factories, large savings in power are effected by electric motors which do away with long lines of shafting, belts, gears, and the like; the building construction may be made less heavy, and the better illumination of workrooms, cleanliness and flexibility of power, and the economy resulting from the introduction of electricity prove in almost every case that the old methods of driving machinery were inferior. Despite its present state, the motor of twenty-five years ago was but a plaything.

In hotels the electric motor operates ice-cream freezers, chopping machines, apparatus for polishing and cleaning silver, dishes and glassware, bread mixers, dumb-waiters, elevators, ventilating fans, annunciators, telephones, call bells, fire alarms and other signaling devices, all exemplifying the myriad uses of electric current, while the field of decorative lighting opens up exhaustless possibilities in the way of beautifully artistic work.

The lumber regions have also benefited by electrical progress. Motors are now arranged to drive portable sawmills with great advantage. Logs are cut at the felling point of the tree, and the haulage of waste lumber is avoided. Wires are easily looped back on trees to the portable generating plant. The advantages of bringing the tool to the work have long been recognized in the mechanical world.

Vast amounts of crude copper are annually refined by electricity. Gold and silver are also successfully treated, and practically all metals may be welded by powerful electric current. Carborundum, an abrasive nearly as hard as the diamond, is now manufactured in large quantities at Niagara Falls by the fusing of coke and sand in the electric furnace. Aluminium, which, not many years ago, cost $2 an ounce, now sells at about 2 cents an ounce, or even less—thanks to the electrical process of separating it from its ores. It is now an active competitor of copper in the wire trade.

Still another industry which has grown up at Niagara upon the basis of cheap power and the union of electricity and chemistry is the manufacture of calcium carbide. This compound is produced by the union of coke and lime through the enormous heat of the electric furnace. In contact with water it produces the well-known illuminant, acetylene gas. Bleaching powder is also manufactured on a large scale at Niagara, which has become one of the greatest electrochemical centers in the world. Even the diamond, in small specimens, has been artificially produced by the electric furnace. Another example of the usefulness of electrochemistry is found in the plating of objects with nickel, gold, silver, copper and other metals.

It would be unfair to leave this branch of electrical work without mentioning the storage battery, perhaps the most conspicuously successful and useful product of electrochemical science. Its value as a regulator and conserver of energy in lighting and railway plants is more generally recognized every year, and it fills an important position in telephone, telegraph, automobile, surgical, fire alarm, yacht lighting, railway signaling and central station work.

In the domain of medicine and surgery the X-rays have proven a well-known and valuable aid to diagnosis. As a method of treatment they have opened up a field of investigation most fascinating to the physician and surgeon. Combined with the emanations from radioactive substances, there is hope that radical progress in the fight with disease may be ultimately attained. To the pure scientist, the X-rays constitute a fascinating means of attacking the constitution of matter itself.

Closely allied to the phenomenon of X-rays are questions of vacuum-tube illumination. For a number of years the problem of supreme importance in artificial lighting has been the attainment of greater efficiency in terms of energy input and light output.

Even the familiar incandescent lamp wastes, in the form of heat losses, about 95 per cent. of the energy supplied to it. Experiments with electrical discharges through mercury vapor have resulted in the production of an interesting and brilliant form of artificial light which appears to have a much greater efficiency than previous forms of illumination, at the same time having useful photographic properties. The disadvantage is the rather ghastly color given to objects illuminated in this way.

Another form of electric lamp which gives great promise of success consists of a "glower" or pencil of rare oxides, which conducts electricity when heated to a state of incandescence. In the last decade great improvements have also been made in electric arc lamps, so that this type of light may now be operated in much smaller units and by a greater variety of electric current than ever before. The old "open type" arc lamp has been largely superseded in interior lighting by the modern "enclosed" form, and the superiority of the latter is so evident from experience that the illumination of city streets is undergoing a similar change. With many able inventive minds bent upon the lighting problem, there is reason for hope that the future will witness great advance toward more efficient forms of light, even if the ideal illumination of the firefly remains an elusive will-'o-the-wisp to engineers. It has been a long way from the carbon pencil arc lamp of Sir Humphrey Davy to the artistic, subdivided light of present practice.

On the foundation of electric lighting has grown up the great central station business of the world. This type of plant was one of the earliest developments in the field of large currents, and from the early days it has maintained a leading position in the electrical field. The expansion of the last ten or fifteen years has been literally tremendous, however. Thus, in 1890, the New York Edison Company's total connected load or apparatus capable of drawing current from its stations was the equivalent of about 100,000 16-candle-power incandescent lamps, while on November 30, 1903, the number of equivalent lamps reached a total of 2,700,000!

Not only has the central station learned to supply current for lighting, but it now also generates and distributes electricity for almost every conceivable domestic and industrial purpose. Great advances in operating economy have been made by the securing of motor business in the daytime. Electrical machinery operates most efficiently when working up to its full rated capacity and, for this reason, the supply of current for industrial purposes in the daylight hours, when the lighting business is small, is a profitable undertaking for the central station. In 1890 the New York Edison Company's motor business was almost too small for consideration, but in 1903 it attained the equivalent of nearly 1,150,000 incandescent lamps.

It would be difficult to name any more interesting example of the transformation of energy than that which the modern central station presents. Starting with the liberation of the stored-up energy of coal through the combustion of that fuel in the boiler furnace, we may trace the transformation through the steam boiler, engine and dynamo, to the great network of distributing circuits which supply current for the myriad uses of city life, from driving printing presses and elevators to lighting tiny dental lamps and operating the sewing machines of hundreds of households. The greater safety, cleanliness, flexibility and convenience of the incandescent lamp long ago made it a successful competitor of gas, and in many parts of the United States, particularly in the West, the older form of illumination has been driven to the wall.

The long-distance transmission of power may be rightly classed among the greatest triumphs of electricity. Its success in regions where the cost of fuel is high has been most marked. So great has become the development of this branch of electrical work that one finds transmission plants scattered all over Europe and America, and even Asia and Africa are falling into line.

Probably the most conspicuous example of this utilization of the power of falling water is found at Niagara Falls. For about ten years the electrical development of this great power has been the admiration of the scientific world. The 26-mile transmission to Buffalo at a pressure of 11,000 volts was long regarded as the climax of achievement in this direction, but today transmissions of from 100 to 200 miles are found in standard practice, while the pressure of the current has crept up step by step to 60,000 volts.

Among the latest undertakings of this character one of the most noted is the harnessing of the Mt. Rainier glacier, in the State of Washington, for transmission of power to Seattle and Tacoma. The distance in this case is not far from 40 miles, but the great height of water-fall (870 feet), the size of the ultimate plant (about 40,000 H. P.), and the line voltage of 60,000, the final development, make the project one of special interest.

In Colorado, the mining machinery of the Cripple Creek gold district is run by electrically transmitted power, and all through the Rocky Mountains, the Sierra Nevadas and the Cascade Range one finds these plants. Even the small water powers of New England and the Atlantic States are thus being turned to account. Numerous examples could be cited in America of cities whose street car and lighting service is operated by water power from 10 to 100 miles away.

On shipboard, electricity has also gained many advocates. It is applied to-day to all manner of purposes, such as operating cranes and ammunition hoists, turret turning, gun training, automatic alarms, search and incandescent lights, call bells, telephones, engine-room signals, forced-draft and ventilating fans, machine driving and wireless telegraphy. It has been used in annealing the toughest steel armor plates, in firing mines, for military telegraphs, range-finders, and the like. Electricity is one of the most useful means of sending messages known to modern warfare.

Turning again to the broader field of communication, we cannot but believe that the art of telegraphy will some day expand to a still greater usefulness than it even has at present. For many years inventors have striven to perfect apparatus which would be capable of transmitting hundreds of words a minute, and there is reason to believe that the time is not far distant when such appliances will be in commercial operation. The importance of high-speed telegraphy to the business world will then rival the post-office itself. The sending of two or four messages over a wire at a single time without interference is an everyday fact in modern telegraphy.

Ocean signaling is now almost universally effected through the delicate and beautiful siphon recorder, which draws a record upon a moving strip of paper, and thus eliminates the old-time tax upon the eyesight and memory which was a part of the use of the "reflecting galvanometer." The discoveries and inventions which have led to the successful spanning of the Atlantic by wireless telegraphy are also full of promise, and the commercial establishment of the wireless systems is eagerly awaited by the entire civilized world. Already a large number of warships and ocean liners have been fitted with wireless outfits and are using them constantly and successfully.

Simultaneous telegraphy and telephony is also being successfully applied to short lines of railroad in this country. In telephone work, the equipment of the central office has un-

dergone many improvements in the past decade. Every effort has been made to give the subscriber quicker, easier and farther-reaching service. The supply of current for both signaling and talking purposes now comes from the central office itself in all standard installations, and in some parts of the country exchanges have been built which entirely do away with central office operators in local service. On the business side, all manner of different rates and contract forms have been devised to suit the tastes and means of the public. Telephone engineering has become a specialized work, requiring the utmost skill and highest degree of technical and business knowledge for success. Perhaps no other branch of electrical work demands such an all-around knowledge and at the same time such mastery of scientific details.

An application of electricity which has proved to be of the greatest value as a safeguard to life and property is found in railway signaling. One of the most interesting examples of this work may be seen in daily operation upon the Boston Elevated Railway. On this system the block signals are automatically moved by the trains themselves, by compressed air controlled by electro-magnets. The entrance of a train upon a section of the track called a "block," operates the electro-magnets to throw the signal just behind the train to "danger," at which position the signal remains until the train passes out of the block section. The signal then returns to the "safety" position, permitting the succeeding train to enter the block. The Boston and Albany division of the New York Central & Hudson River Railroad is also equipped with automatic electric signals throughout its entire main line, as are numbers of other steam railways in the United States. The telegraph and electric signal systems are two well-nigh indispensable factors in the safe and expeditious handling of modern railway traffic.

The field of agriculture has been, to a limited degree, invaded by electricity. Experiments upon the electrical stimulation of crops have met with at least a modicum of success, and it is certain that the future holds in store some notable triumphs in accelerating the growth of plants and vegetables. An ingenious electric recording instrument is in use to-day, especially in Europe, which informs the farmer of the total fall of rain, the time of its duration, the exact time of its commencement and cessation, the interruption in twenty-four hours, duration of maximum downfall and the rate of precipitation at any time throughout the storm. Still another instrument foretells the advance or recession of storms by the electrical condition of the atmosphere.

Thus far electricity has not been extensively applied to farm work for lighting and power supply, although some notable instances are found here and there. Through its ease of transmission and subdivision into small powers, the electric current is peculiarly adapted to agricultural works, especially as it requires little attention or oversight. An interesting example of advanced farm practice is found at Prottorf, Saxony, where a number of adjacent farms are supplied with power from a central station for operating threshing machines, lights and motors. An electrically driven plough is now on the market, and in Algeria electricity propels and operates an interesting collector, whose function is the picking up of grapes and the carrying of them to the press. By far the most important electrical apparatus applied to farm life is the telephone, however. As was implied previously, the extension of this device to rural fields is proceeding by leaps and bounds in America at the present time.

Perhaps the engineering progress of the last century, which has made possible the industrial development of to-day, owes more to iron and steel than to anything else. Certainly the marvellous adaptations of science to the ever-expanding needs of civilized life would scarcely be thinkable without the existence of mining. In the last analysis, the earth is the great repository of all our material wealth. It is gratifying to think that the achievements which the mine has made possible have in return vastly increased the processes of mining themselves in flexibility, economy and safety.

In the early days of mining, almost all the work was done by hand, with pick and wedge. Ventilation was neglected and the drainage of water accomplished by crude and ineffectual methods. The product of the mine was hauled to and fro by laborious human or animal power, and the problem of obtaining adequate, clean light was unsolved. To-day the difference in operating methods is very great. In the metalliferous mines of America, electricity is being used in every operation. It drives pumps, hoists, air compressors, drills, elevators, coal-cutting machines, stamp mills, screening, crushing and grinding machinery; it turns great fans, supplying many thousands of cubic feet of air to shafts and levels each minute; it lights the deepest gallery, does away with greasy, oily lamps; the wires may run anywhere without regard to turns and bends; leaky and wasteful steam-pipes are eliminated, and the ore is hauled by electric locomotives with ease and economy of time and power.

Telephonic and bell signalling place the innermost workings in instant connection with the superintending offices, and blasts are safely fired from a distance by the electric current or spark. Simplicity of design, ease of control and portability, added to high efficiency and safety, constitute the chief advantages of the electrical apparatus, which is driving out all competitors in present-day extraction of metals from the earth. In the famous Cripple Creek district of Colorado, electricity is practically the only power employed, and the entire region is served by an interesting and frequent-running system of trolley cars.

The underground electric locomotive has been in use in America for fifteen years, and there are now about seven hundred of these machines in operation in this country. Enormous economies have resulted from the substitution of electricity for steam power in mining. In the Cripple Creek district, which is located at altitudes of from 8000 to 11,000 feet above the sea, the cost of the water supply for boilers at some of the mines was equal to the cost of coal itself, as far as transportation was concerned, before the advent of electric power.

The large diamond mines of Kimberley, in South Africa, utilize electricity throughout their entire system of mechanical apparatus. From the driving of rock drills and hauling of the "blue ground," which contains the diamonds, to the surface of the mine, up to the final sorting of the precious stones, electricity is employed for every possible operation. Even the cabins of the ten thousand native employees are lighted by the electric current distributed according to the best modern practice.

In the manufacture of steel rails, electric motors have replaced steam engines in the driving of metal saws, roll tables, trains, rail conveyors and machine tools. They also hoist the ore to the top of the blast furnaces, empty the molten metal into the Bessemer converters—in short, they make the process of rail manufacture so nearly automatic that the material and product are not touched by human hands, but are simply guided throughout the entire range of operations which convert the iron ore into a steel rail. In the foundry, as well, the electric crane and hoist have now a firm foothold.

Had not this imperfect view of the electrical field already outgrown its intended dimensions, it would be interesting in emphasizing some of the great and small developments, to conclude with a sketch of the triumphs of

electricity in the domain of transportation. The expansion of the small city street railway system into the interurban line, and the fast approaching conquest of the steam locomotive in suburban railroad service by the electric motor cannot be adequately pictured in a single paragraph. Slowly, but surely, the electric railway is learning the lessons which nearly eight decades of hard-earned experience have taught the steam road, and steadily is electric transportation coming to be the great successful rival of every other method known to mankind. Every elevated railway in the world has signed the death warrant of its steam locomotives; the cruelties of horse traction have been abolished; the trolley car has "doubled the available area of cities and towns," carried the workman to a new home in the more healthful and less crowded suburbs, saved an incalculable amount of time to every street railway passenger, and finally the electric locomotive has begun a campaign which will inevitably drive the steam locomotive from the limits of great centers of population in civilized lands.

In closing this limited sketch of the position of electricity in these early years of the twentieth century it is well to realize that the triumphs which have been attained rest upon the patient labors of many different men. Individual investigators have accomplished marvels in invention, but the foundation of it all goes back to the work of many minds—minds like those of Hertz, Maxwell, Helmholtz, Faraday, Henry, Davy, Franklin, Cavendish, Volta, Oersted, Gilbert and many other scientists, long since passed to their reward. Honored as these men are by the student of electrical history, there is room for far greater appreciation of their priceless service. That such master intellects laid the foundations of the great science of to-day must ever remain the crowning glory of electrical ancestry.

Problems of Heavy Traction

PROBLEMS BEFORE THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

ABOUT two years ago an effort was made by the American Institute of Electrical Engineers to induce such of its members as might have in their files data that would be of great value to the electrical engineering profession at large, to present such data to the Institute, either in the shape of a paper or otherwise for publication. While there can be no question that many of the members must have valuable data for such a purpose,—the result of actual experiment or practice,—there was no response to the appeal.

At a recent meeting of the Institute, however, held at Carnegie Hall, New York, on November 25, an interesting paper which followed the lines just indicated was presented by Messrs. O. S. Lyford, Jr., and W. N. Smith. It treated of "Problems of Heavy Traction." It bore upon some of the questions that were brought out in connection with a study of the engineering problems involved in the extensive plans for the electrification of the suburban service of the Long Island Railroad that have been under consideration for some years. The paper is replete with formulæ, tables of tests and curve sheets, tabulated and plotted by the authors and others, dealing with the average speed and watt-hours per ton-mile; comparison of test and theoretical train curves, using actual braking curve; general performance curves; acceleration curves, etc.

The authors acknowledged that a number of valuable papers have been contributed to the general literature of these highly important subjects within the past few years, but implied that while some of these were scholarly and, in a sense, academic, they involved a great deal of calculation, the necessity for which was questioned. Further, while the subjects of train resistance, acceleration rates, and rating of motors have been reported on at length, generally from different standpoints, other important matters involved in heavy electric traction, such as the effect of the inertia, of the rotating parts of the train, had previously been overlooked.

But with all the data at hand, some very important questions are still left for settlement by the engineer approaching a solution of the problem under consideration.

The first of these questions is, in view of the somewhat conflicting reports and statements of other engineers, Who is right? Other questions are, How much of the tedious calculation described in previous papers is necessary? How much power must be delivered to the motor cars to move a train from one terminus to the other, whether this power is used to overcome mechanical friction, head resistance, gravity or inertia? How close will practice work out to theory? What allowance must be made for local limitations on the possible speed of train equipments?

In order to obtain satisfactory answers to these queries the authors undertook many experiments and investigations, some of which are described in this paper. The conclusions of the authors were that a study of the operating conditions of even a complex project quickly narrows the selection of motors down to one or two sizes, and that these conditions also largely determine the speed characteristics of the equipment; further, theoretical methods are now developed to a point of sufficient accuracy to be considered reliable for purposes of selecting equipment; and finally, short methods of predetermination may be used with discrimination, at least for preliminary predeterminations.

The discussion that followed the presentation of the paper was perhaps quite as interesting as the paper itself. Mr. L. B. Stillwell, who opened the discussion, gave a number of interesting items of information drawn from his experience with the electrical work of the New York subway. Mr. C. O. Mailloux, whose pioneer paper relative to electric motors for railway service, head resistance, etc., had been classed among those referred to by the authors as scholarly, academic and somewhat bewildering, created much amusement in disclaiming the implied compliments as to the scholarly and academic quality of his paper, but thought that some of the very flattering letters which he had received, and extracts from which he read, from certain prominent engineers who had used his paper in their work until it was worn out, were a sufficient answer to any statement as to its bewildering character.

Mr. A. H. Armstrong followed Mr. Mailloux. In the course of his remarks he took occasion to say that he had come from Schenectady at the rate of 62 miles an hour to take part in the discussion. He pointed out numerous apparent discrepancies between the various curve sheets, and his remarks, while quite relevant to the subject, for some time partook somewhat of the nature of a dissection rather than a discussion of the paper. Mr. Armstrong also contributed some of the experience gained in the design and practice of single-phase motors at Schenectady.

The authors replied to the points raised in the discussion.

Mr. Smith noted as a somewhat curious fact that another investigator had obtained results directly opposite to those mentioned by Mr. Stillwell, in which his experience had shown that at the moment of starting the tractive

effort was 10 per cent. greater on the rear axle of the car truck than on the forward axle.

Mr. Lyford, who closed the discussion, pointed out that the main object of tests such as those described was to obtain data which would enable a consulting electrical engineer to prepare a report that would be clear to the hard-headed business man, enabling him to reach an understanding of the situation—one upon which he could intelligently base his own conclusions. He thought that some of the criticisms of the paper savored of the methods employed by certain designing engineers in discussing the apparatus of rival manufacturers.

The meeting adjourned at 11:15 p. m. Admitting that some of the rather adverse criticism of parts of this paper may have been invited, it is perhaps doubtful whether other engineers will hereafter feel disposed to submit more or less similar data in their possesion, for public discussion. Of course an important object in presenting papers before a scientific institution is to elicit discussion, but it should be borne in mind also that the raison d'etre of such institutions is the advancement of the art and science, and that the advantage that may accrue to commercial organizations by a felicitous presentation of a subject in a paper, or that may be detracted therefrom in a skillful discussion of the paper are not the main things to be considered. Likewise, that it is generally more difficult to build up than to tear down—a common laborer is sometimes competent to demolish a building, the construction of which required the combined brains of an architect and builder.

The presentation of but one paper for consideration on this occasion was a return to the former custom, and it was the general opinion it was a good practice.

The Electric Motor for Speed Regulation

By Dr. SCHUYLER S. WHEELER

THAT an electric motor is useful chiefly because it affords a means more convenient than any other of running machinery at different speeds, or at an exceptionally steady speed it is a comparatively new idea, but it is spreading so rapidly that it attracts much attention. Electric power was originally introduced because of its economy, simplicity, and ability to bridge distance; but lately another virtue, heretofore comparatively unobserved, is being studied, or rather, its sponsors, finding that the world has grown to value it, chiefly on account of its use for regulation, are studying to produce more and greater results along this line.

The reason why the feature of regulation and control of speed is assuming this position of paramount importance compared with the other features, such as transmission economy, for example, is easily explained. The simplest possible form of an electric motor is the shunt-wound machine, and this, when connected with the ordinary electric lighting circuit of today, runs at a steady speed, drawing hardly any current until it is required to furnish power, and at that moment it consumes power only in proportion to the work done. If connected to a circuit of lower pressure, it will run equally well, but at lower speed. If required to make extra effort, as in starting machinery, it will furnish up to five times its full power without trouble. When running free, if its speed is increased by the application of external power, as by a belt, it becomes a dynamo and pumps current into the line; this, in turn, throws work upon the machine and tends to slow it down. The machine is, therefore, in itself a factor, tending to the preservation of constancy of speed and to the preservation of constancy in the pressure on the circuit, its momentum tending to steady the pressure on circuits which fluctuate, and it is ideal in its simplicity, having absolutely no governing or accessory parts.

To obtain any speed desired, it is only necessary to supply the armature of the motor from a circuit of lower or higher pressure to correspond, when the motor will run slow or fast in nearly exact proportion to the pressure supplied. This principle is the foundation of the best methods of today for speed variation, whether it is put into effect by resistances used in connection with the machine for cutting down the pressure or by the use of different circuits supplying different original pressures. The ability to do at once all of these things is absolutely without parallel or comparison in any other kind of prime mover, and explanations of the operation of the electric motor are consequently attended with a little difficulty, because there is a lack of points of similarity with other engines.

A steam engine, for example, will stall when its ordinary capacity is exceeded, and it is governed by external apparatus which often becomes deranged, and which may act too late to prevent fluctuations in the speed; again, the operation of the engine is entirely different from that of the motor in that it is not capable of reversing its action under fluctuating conditions. For example, if for any reason the boiler pressure runs low or the engine speed runs high, the engine will not pump steam into the boiler to assist in maintaining the steadiness of the system; again, the engine cannot have its speed changed at any moment when a different speed is desired, nor operate with equal economy at different speeds.

The shunt-wound motor runs at practically constant speed under all loads, and if closer uniformity of speed is desired, it can be arranged to run within any desired limits of variation by setting the brushes in a position shifted slightly from their usual place, or by adding to the field winding a few turns, connected in series with the armature, and reversed in comparison with the main winding. Either of these arrangements causes the motor to speed up under load, and the extent of this action may be adjusted to equal precisely the tendency ordinarily met of slowing down under load.

When variations of speed are desired they are obtained by the use of different pressures to run the motor, the speed in each case corresponding very closely to the pressure employed. These pressure changes are made either by running the current through a resistance or rheostat, which cuts it down, but interferes with the constancy of speed; by adjusting the generating dynamo so as to yield a high or low pressure, or by the use of multiple circuits to give different pressures. When the last-mentioned plan is used, a number of conducting wires, each connected to a separate source, so that each wire will give a different pressure, are run around the building to each motor. This system may be compared with the method of writing music and the several wires to the bars of the staff. The speed of each motor will be high or low, according to the bar to which it is connected, in the same way that the musical notes are high or low. The method, however, is limited to cases in which the motors are not located very far apart.

The starting up of motors is a part of this same subject, being a case of control for brief periods, and as they can be started and stopped so easily and quickly they have, again, a great advantage. The operations necessary are the same as those for speed control. The motor's speed is regulated

(controlled) from slow to fast at short intervals sufficient to allow the connected machinery to be set in motion without violence.

While the above is an outline of the more important principles underlying the subject, and is the basis of practically all of the commercial applications of motors, there are really nine different methods by which the speed of a motor may be varied:—

1. By throttling or inserting resistance in the armature circuit. 2. By changing the circuits within the machine. 3. By changing the magnetic parts of the machine. 4. By varying the strength of the field electrically. 5. By varying the time average during which the current is applied to the motor. 6. By rotating the commutator brushes. 7. By the use of a number of circuits, each supplying a different potential. 8. By changing, at the source, the pressure which operates the motor. 9. By adding to or reducing the pressure from the source by the use of an auxiliary pressure.

These are mentioned in their approximate order of invention. Several have not been found useful, and are, therefore, of scientific interest only. There are numerous ways in which each may be carried out, and the devices resulting from combining two or more, several of which combinations are extensively used, are almost innumerable, and their description would not be appropriate here.

The purpose of this article is to draw attention to the following leading facts pertaining to the general subject:—

First.—The electric motor's regulation and control are the most valuable of its good attributes.

Second.—It is unique and remarkable in the accuracy, scope and adjustability of its regulation. It maintains a speed which is nearly constant and is not deranged by great overloads. It may be adjusted to run with a constancy of speed within any limits of precision, and its action swings about this fixed speed as a center, its activity increasing as a motor if it is slowed down by heavy load, and becoming that of a dynamo and reversing the demand for current if speeded up by the application of extra power.

Third.—It achieves this remarkable regulation when made in the simplest form and without any governor, valve or other apparatus.

Exports and Imports of Copper of the United States

According to statistics compiled by the Department of Commerce and Labor, the amount of copper ore exported from the United States to Great Britain, Germany, Mexico and other countries during the nine months ending September, 1904, was 12,965 tons, having a value of $826,427. Ingot, bar, plate and old copper were exported to the amount of 402,391,932 pounds, valued at $51,266,988. All other copper manufactures exported in the same period were valued at $2,218,918.

The imports of copper ore, matte and regulus for these nine months from Germany, British North America, Mexico, South America and other countries were 185,563 gross tons, equivalent to 26,061,272 pounds of copper, valued at $2,901,814. Pig, bar, ingot, plate and old copper were also imported to the amount of 107,668,097 pounds, valued at $13,744,435. The dutiable manufactures of copper imported were valued at $28,544.

Brief Topics of the Month

Plans are said to have been perfected for the construction of an electric railroad, 248 miles long, in Mexico. It is to run from Guadalajara to Morelia. The Catholic Bank, of the City of Mexico, will finance the project.

The New York, New Haven & Hartford Railroad Company, it is stated, is now equipping its passenger cars with storage batteries, which will furnish light for all trains between New York and Boston.

The annual report of the Philadelphia Rapid Transit Company gives the total number of passengers carried during the year ending June 30, 1904, as 390,532,689, an increase over 1903 of 24,624,638. The receipts from passengers were $15,923,507,87, an increase of $645,701.29. The operating expenses were 50 1-5 per cent., or $7,993,314.75, an increase of $758,421.98. The operating expenses, including licenses and taxes, amounted to 56 86-100 per cent.

The council of the American Institute of Mining Engineers has decided that the only practicable method of participation of the Institute in the gift of Mr. Andrew Carnegie in the shape of the united Engineering Building is the immediate incorporation of the Institute under the laws of the State of New York. To that end, a special meeting of the members and associates will be held at the office of the Institute, 99 John street, in the city of New York, on December 29, 1904, at 2 o'clock in the afternoon, to consider and vote upon a resolution authorizing such proposed incorporation.

The first complete system of public electric fire alarms was provided in connection with the police stations in Berlin in 1849.

A suit brought by the General Electric Co. against the Duncan Electric Manufacturing Co., of Lafayette, Ind., before Judge Anderson, in the Circuit Court of the United States, in Indiana, was recently decided in favor of the latter company. The complainants claimed infringement of patents held by them on electric meters.

A game of chess was recently played by the officers of the United States cruiser "New York and of the cruiser "Boston" by means of the wireless telegraph. Both ships were cruising along the California coast and were several miles apart.

The production of aluminium in the United States was 7,500,000 pounds in 1903, 7,300,000 in 1902, 4,000,000 in 1897, 1,300,000 in 1896, 61,281 in 1890 and 83 in 1883.

A Cleveland restaurant has installed two telephones for its patrons' use. Seventy plugs are arranged along the tables so that the telephones may be used at any seat.

Of the total number of telephone lines in operation during 1902-1903 in Great Britian, 44,141 miles were overhead, 2167 miles were underground, and 2746 miles were submarine.

April 30, 1905, will be the tenth anniversary of the publication of the discovery of the Roentgen rays. A congress will convene in Berlin on that date, at which Prof. Roentgen will be the guest of honor.

A fire alarm system installed in the Colonial Hotel, in Cleveland, Ohio, provides for the simultaneous ringing of bells in 200 rooms by the closing of a switch in the office.

A lighthouse is now being constructed on Lennard Island, off the west coast of Vancouver Island, which has what is said to be the most powerful electric light in Canada. It is of 750,000 candle-power and can be seen for 25 miles.

An electric railroad was recently put in operation in Mandalay, which is the first city of Burmah to substitute electric for horse traction. The line is double-track, 7 miles long.

Electrical and Mechanical Progress

Electricity on the U. S. Battleship "New Jersey"

WITH the possible exception of the battleships "Kearsarge" and "Kentucky," the use to which electricity is put on the United States battleship "New Jersey" exceeds in extent that on any other similar ship in existence.

All the turrets have electrical turning gear, and the ammunition hoists, blowers for the turrets and general ventilation, the general workshop, and practically all of the auxiliaries, outside of the engineers' department, and excepting capstan and stearing gear, are to be electrically driven. To provide the current required for these purposes eight engines and dynamos will be installed, mounted on combination bed plates, two having a rated output of 1,250 amperes at 125 volts, and six of 62.5 amperes at 125 volts.

Commutator Truing Devices

THE inconvenience of removing an armature from a motor or generator for the purpose of truing the commutator is at once apparent when the weight of the armature and the steps necessary for its removal and placing in a lathe are considered. To allow of the operations being more readily performed, the Fort Wayne Electric Works, of Fort Wayne, Ind., has designed three forms of commutator-truing device, shown in the annexed illustrations. This device was originally intended for use on the company's machines only, but it has since been changed to allow a wider application.

Fig. 1 is the shaft type of truing device for mounting directly on the shaft of the armature or on the pedestal of small machines having removable bearing caps. In many cases where it is not convenient to remove an armature from the bearings this device is very satisfactory. In street car barns and repair shops work of this nature can be done at night, not only saving time but also obviating the necessity of carrying a stock of spare armatures. In fact, railway motor commutators can be trued without removing the

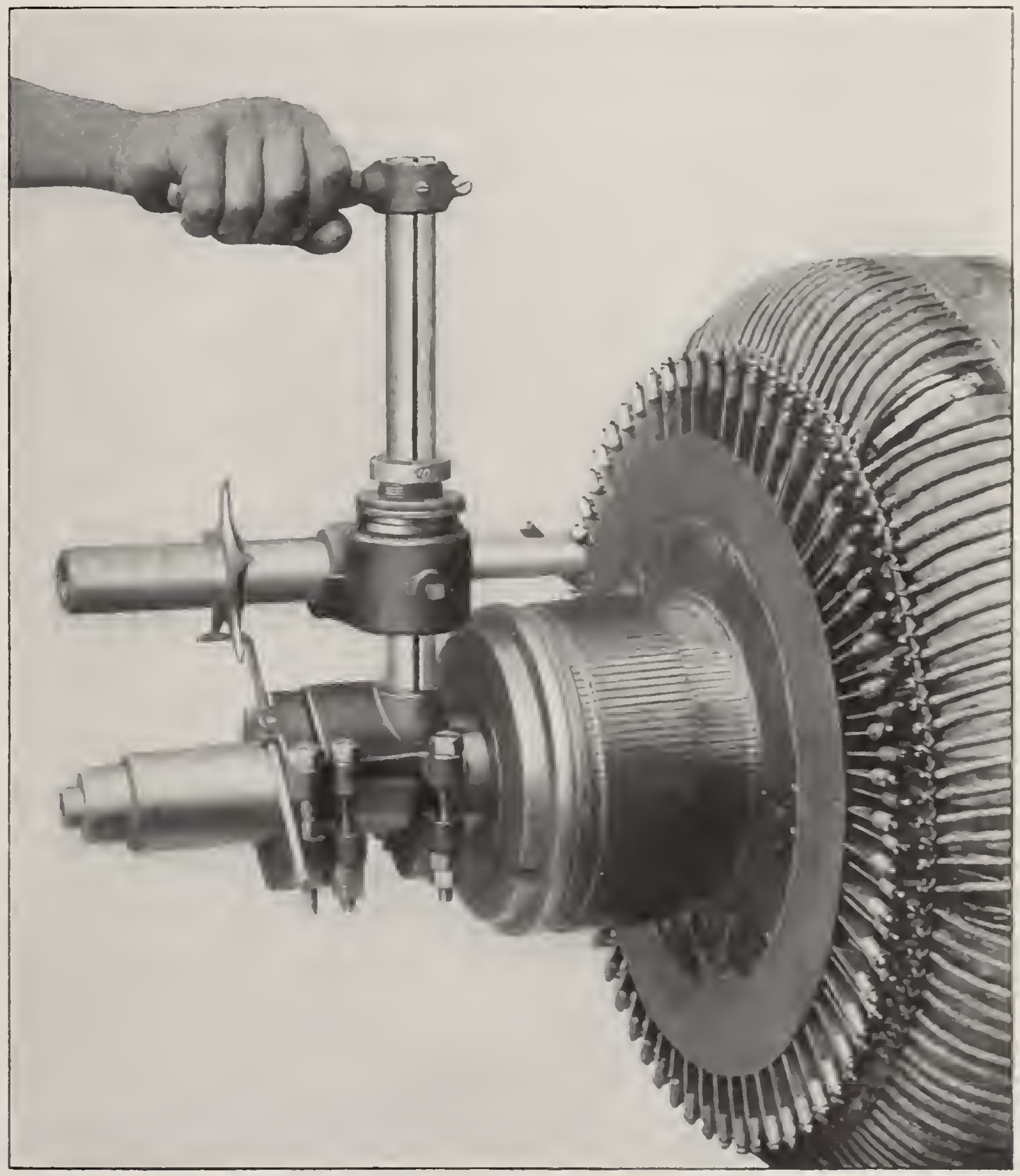


FIG. 1.—A SHAFT TYPE OF COMMUTATOR TRUING DEVICE MADE BY THE FORT WAYNE ELECTRIC WORKS, FORT WAYNE, IND.

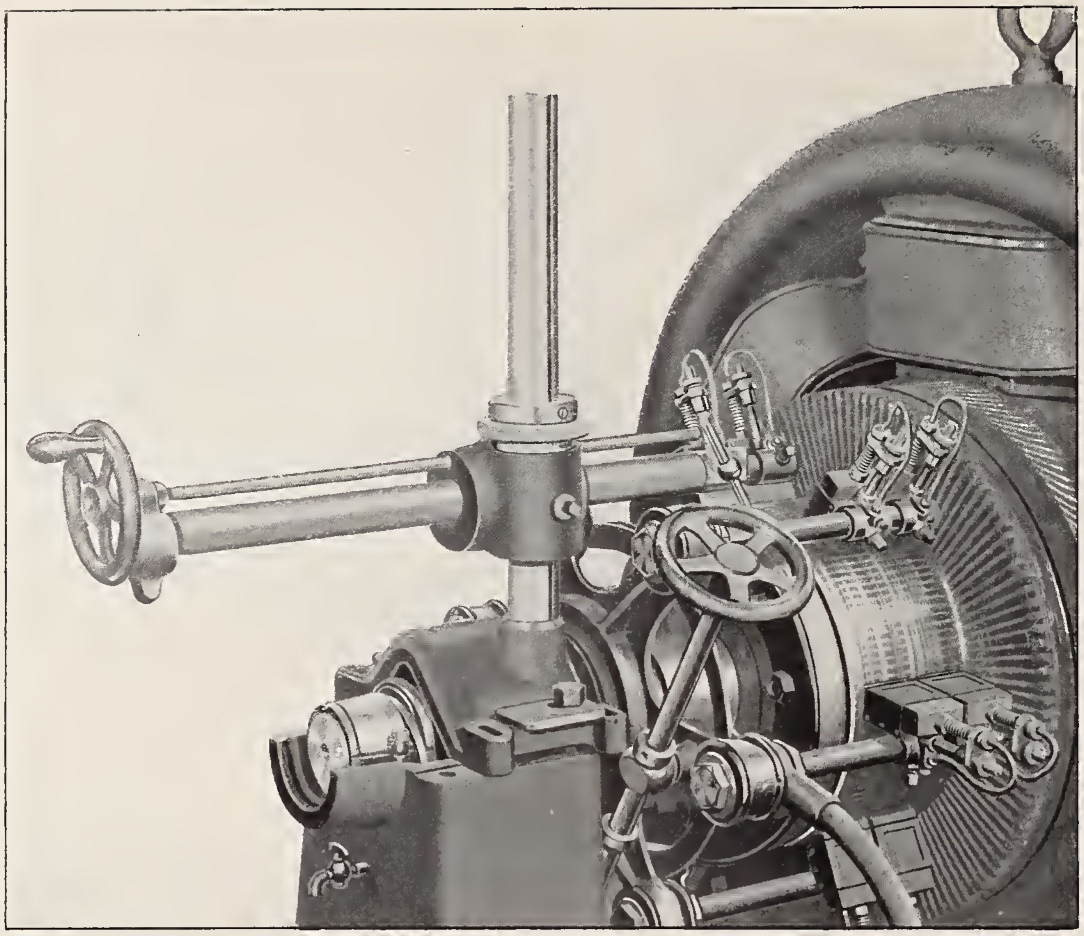


FIG. 2.—A COMMUTATOR TRUING DEVICE FOR MOUNTING ON THE BEARING PEDESTAL, MADE BY THE FORT WAYNE ELECTRIC WORKS

armature from the pit, a valuable feature for periods of heavy traffic.

When mounted on the shaft, as shown in Fig. 1, the armature is stationary and the device is revolved around the commutator with the shaft as a bearing, and the tool is moved across the commutator by a screw feed actuated by a detent clamped to the shaft. This produces a perfectly true surface concentric with the shaft so that the commutator will run true when the armature is again mounted in its bearings.

This type has a tool travel from 2 inches to 12 inches radially from the shaft center and 6 inches parallel with the shaft. When mounted on the shaft it will true commutators under 24 inches in diameter, having less than 6-inch face, including the flange.

Fig. 2 shows the pedestal type, intended for mounting on the bearing pedestal in place of the bearing cap. When this device is used the armature is revolved in its own bearings by means of a handle clamped to the pulley. If the bearing bolt holes are not the right distance apart to take the device on its own base, a pair of bolsters are used. The bolsters allow a variation of 4 inches to 15 inches in distance across the shaft between bolt holes. This device can be mounted on any pedestal having dimensions within these limits.

The tool has a horizontal travel of 21 inches beginning 3 inches inside the fastening bolt in the base of the device and a vertical adjustment of 12 inches beginning 4 inches from the center of shaft without bolsters, or 6 inches with bolsters.

Fig. 3 shows the type for generators having brush mechanism mounted on a yoke carried by a field frame. It consists of a carriage for the tool holder having a screw feed and a bracket for attaching to the brush yoke. The bracket replaces two brush holder brackets on the brush yoke and is made to fit the yoke of the particular machine on which it is to be used.

The carriage is made in two sizes, either of which can be used with any one of thirteen different brackets. The size of frame for which this type is adaptable varies from 25 to 800 K. W. As has been stated, any of the three types may be adapted to any make of machine, it being necessary, however, to give certain dimensions to the makers.

A Big Boiler Chimney

WHILE the days of big chimneys for boiler plants may have been shortened somewhat by the development of artificial draught machinery, they are not yet of the past, nor has the business of steam distribution through city streets over long distances been crowded out of existence by the electric central station, despite the many attractive features of electric power service. An excellent illustration of this will be afforded by a chimney to be built for the New York Steam Company, whose steam service for heat and power through underground street mains has been in operation in the city of New York for the past twenty-three years. The chimney, which will form part of the uptown station of the company, is to be 300 feet high, circular in section, with an outside diameter at its base of nearly 30 feet, tapering to about 17 feet at its apex. It will be built in twelve sections, with walls ranging in thickness from 32 inches at the lowest section to 11 inches at the topmost section. The weight of the chimney will be about 2200 tons, and its cost in the neighborhood of $25,000.

A Two-Wire System for Operating Trains of Cars

A NEW system for controlling motor-driven cars operated on the so-called multiple-unit plan has been recently patented by the Cutler-Hammer Company, of Milwaukee, Wis. The unique feature of this invention is that both the direction and speed of the driving motors on the entire train are controlled by means of but two small wires running the entire length of the train, and by the use of a controller of about the same size as a standard field regulator for a 3-K. W. generator.

As may be seen in the accompanying diagram, the two wires constituting the train line are attached at each end of the car to automatic couplings C^1, C^2, which enable the cars to be shifted either end to, thus requiring no attention in coupling so far as the electrical equipment is concerned. The

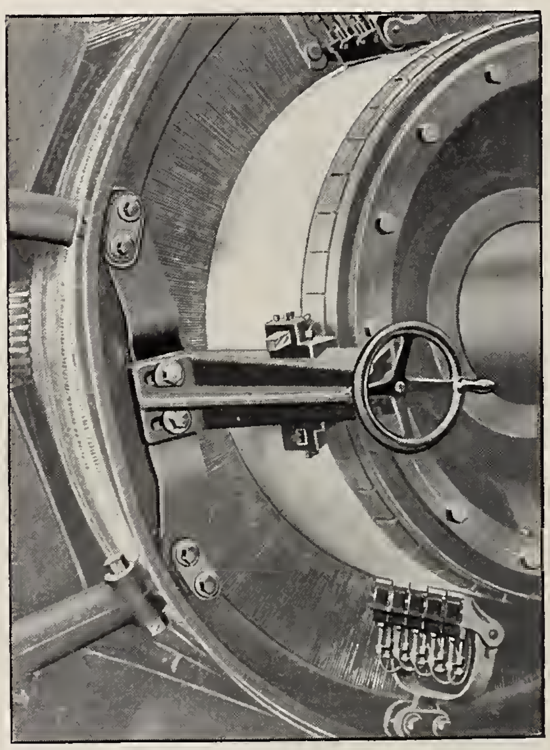


FIG. 3.—A TRUING DEVICE FOR GENERATORS, WITH YOKE-MOUNTED BRUSH MECHANISM

maximum current carried by the two-wire train line is the output of a 3-K. W. 110-volt generator when used in connection with six cars equipped with four motors on each car, the motors being capable of developing 300 H. P. per car or 1800 H. P. per train of six cars. Each car may be equipped with a 3-K. W. motor-generator *m, g,* capable of controlling the speed of the motors of the entire train, or by another method each car can be equipped with a ½-K.W. motor-generator, capable of controlling the speed of its own car only.

The direction of travel of the train is controlled absolutely in accordance with the direction of the current flowing in the two-wire train line, and the speed of the train is controlled by the voltage impressed upon the two-wire train line. These wires are utilized for supplying the necessary current for energizing the windings of a number of solenoid switches, which control the current supplied to the driving motors, M^1, M^2, M^3, M^4, mounted on the trucks.

The two driving motors on each truck are treated practically as one motor, but are provided with an independent solenoid reversing switch *F*, *B*, and two solenoid accelerating switches *A* for cutting out the starting resistance *R*. Two other solenoid switches *S*, *P* are also employed for connecting the motors on one truck, either in series with the motors on the other truck or in parallel therewith, in accordance with the speed desired.

The method of operating the reversing switches in accordance with the direction of the current flowing through the two-wire train line is quite simple. Each solenoid used on the reversing switches *F*, *B* is provided with two windings. One of these windings is permanently connected between the trolley *T*, or third rail, and the ground *G*. The other winding is permanently connected to the train line. The winding on the forward solenoid reversing switch *F* is wound left-handed and the winding on the back-up solenoid reversing switch *B* is wound right-handed. It is evident, therefore, that when the current is flowing in the train line in one direction, it will assist the winding of one of the solenoid switches and neutralize the action of the other solenoid winding, so that the desired solenoid switch will be energized in accordance with the direction of the current flowing in the two-wire train lines. The accelerating solenoids and the series and paralleling solenoids are wound so as to actuate their plungers at different voltages. The operation of the system is briefly as follows:

Let us suppose that each car is equipped with a 3-K. W. motor-generator *m, g.* At each end of the car is installed a 3-K. W. field regulator *f,* having a double set of resistance buttons and segments. An ordinary 3-K. W. 110-volt starting box *b* is also provided. The operator first starts the 3-K. W. motor by means of this starting box. He then moves the field regulator lever f^1 in the direction in which it is desired to move the train. When this lever makes contact with the first step of the resistance, current is admitted through this resistance to the shunt field of the 3-K. W. generator *g*, thereby causing it to impress a voltage on the two-wire train line of, say, 20 volts. This voltage is sufficient to energize the forward reversing solenoids F^1, F^2, and cause them to lift their plungers, assisted by the current taken directly from the trolley or third rail.

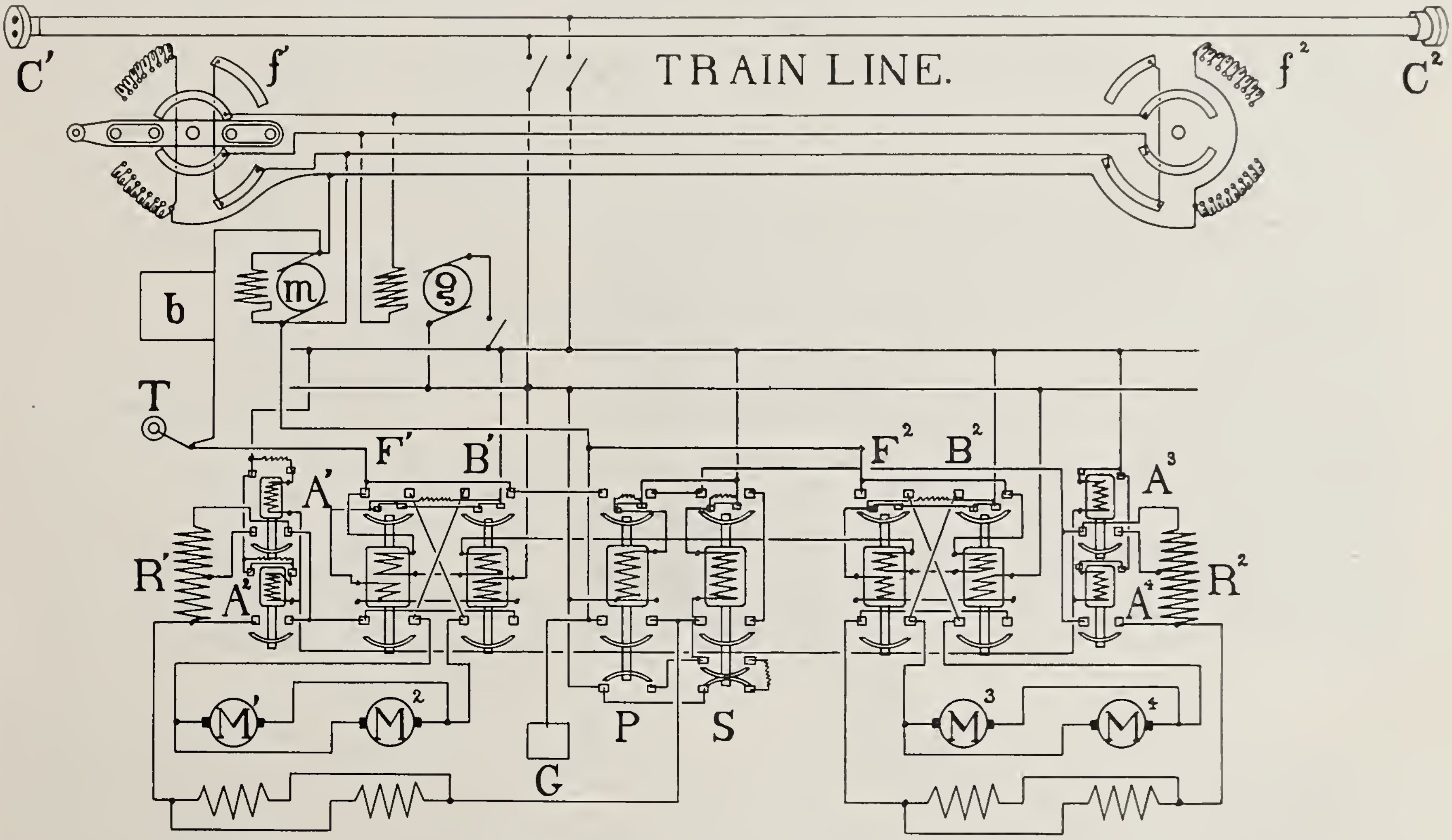


DIAGRAM SHOWING THE WIRING CONNECTIONS FOR THE TWO-WIRE SYSTEM FOR OPERATING TRAINS OF CARS, AS DESIGNED BY THE CUTLER-HAMMER COMPANY, MILWAUKEE, WIS.

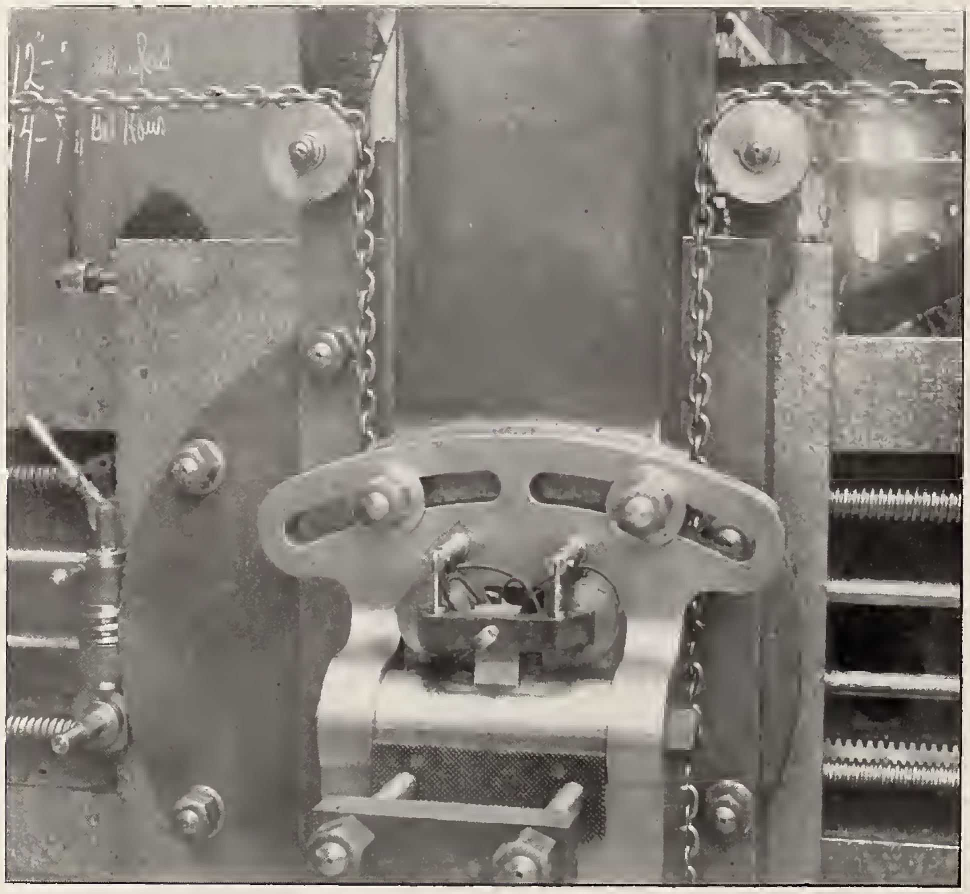
The same voltage also supplies sufficient current to energize the winding of the series solenoid switch *S*, which attracts its plunger and closes the circuit of the four driving motors M^1, M^2, M^3, M^4, in series. The operator then moves the lever to the second notch, increasing the voltage on the two-wire train line to, say, 40 volts, which is sufficient to energize the first of the solenoid switches A^1, A^3 for cutting out the first step of starting resistances R^1, R^2.

The operator then continues to advance the lever, thus gradually increasing the voltage on the two-wire train line until finally the second step of resistances R^1, R^2 is cut out. The

paralleling switch P is then energized and the starting resistances R^1, R^2 reinserted, which resistances are then again cut out until the driving motors are finally operating in parallel at full speed. The only wires which run the entire length of the car are the two train wires, capable of carrying about 30 amperes, and the four-wire cable connecting the two 3-K. W. field regulators, being capable of carrying a small fraction of an ampere in each wire. The solenoid switches controlling the driving motors are assembled in two sets near each truck, so that only four large wires are necessary for connecting the motors on the two trucks in series or parallel.

A second method has been made the subject of another patent, and consists in installing a ½-K. W. motor-generator on each car and varying the voltage of each generator by varying the voltage of the train line. In this case the train line carries current sufficient only for energizing the fields of six ½-K. W. generators at 500 volts, or about 0.6 of an ampere, the field windings being adapted for 500 volts, and the armature windings having a maximum of 110 volts for supplying the solenoid windings on each car.

It will be noticed that there is no operator's switch in the train line circuit, and that the system is different from the usual method of employing a number of wires running the entire length of the train, and utilizing each wire to energize some particular set of solenoids. A still further advantage claimed for the system is in its employing a low voltage on the solenoid windings, as well as on the controlling wires. It is possible to control the entire train by means of one wire, using a rail return, but two wires are preferable for practical work. It is also claimed that it is practically impossible for the operator to too rapidly accelerate the train, for the reason that the potential of the generators used will not respond instantly to changes in the energizing current of their field magnets when designed with this feature in mind. In practice, therefore, the operator has merely to move his controlling lever to the full speed position and the train will smoothly and rapidly acquire full speed without further attention.



A MAGNETIC TOOL-LIFTING ATTACHMENT FOR PLANERS, MADE BY THE NILES-BEMENT-POND COMPANY, NEW YORK

A Magnetic Tool-Lifting Attachment for Planers

AN interesting device for attachment to planers, to lift the tool away from the work and hold it out of contact during the return stroke, has been patented by the Niles-Bement-Pond Company, New York. The purpose of the device is to avoid the wear on the back of the tool which occurs in ordinary practice when the work rubs under the tool during the idle stroke. As may be seen in the accompanying illustration, the device consists of an electro-magnet, which is incorporated in the clapper box and acts upon an armature suspended by a pair of small links directly in front of the magnet, and astride of a tail projecting from the tool apron. At the end of the cutting stroke, the electric circuit is closed, causing the magnet to attract its armature and press against the tail of the tool box, thus raising the free end of the tool. This action takes place automatically at the moment of reversing, and the armature is again released at the end of the return stroke. The action is timed so that there is no need to increase the length of the stroke, and the device works equally well at all positions of the rail or saddles, and at any angle of the swing. Current is supplied to the magnet from an ordinary lamp socket through an extension cord, which is suspended from the top of the planer. The amount of relief given to the tool is regulated by a set-screw from nothing up to its maximum. By the turning of a small switch, the device may be thrown out of action when desired. Its use in no way interferes with the ordinary working of the tool apron, and the latter can be lifted up while replacing the tools without disturbing any part of the tool-lifting device.

A Transformer for Thawing Out Frozen Water Pipes Electrically

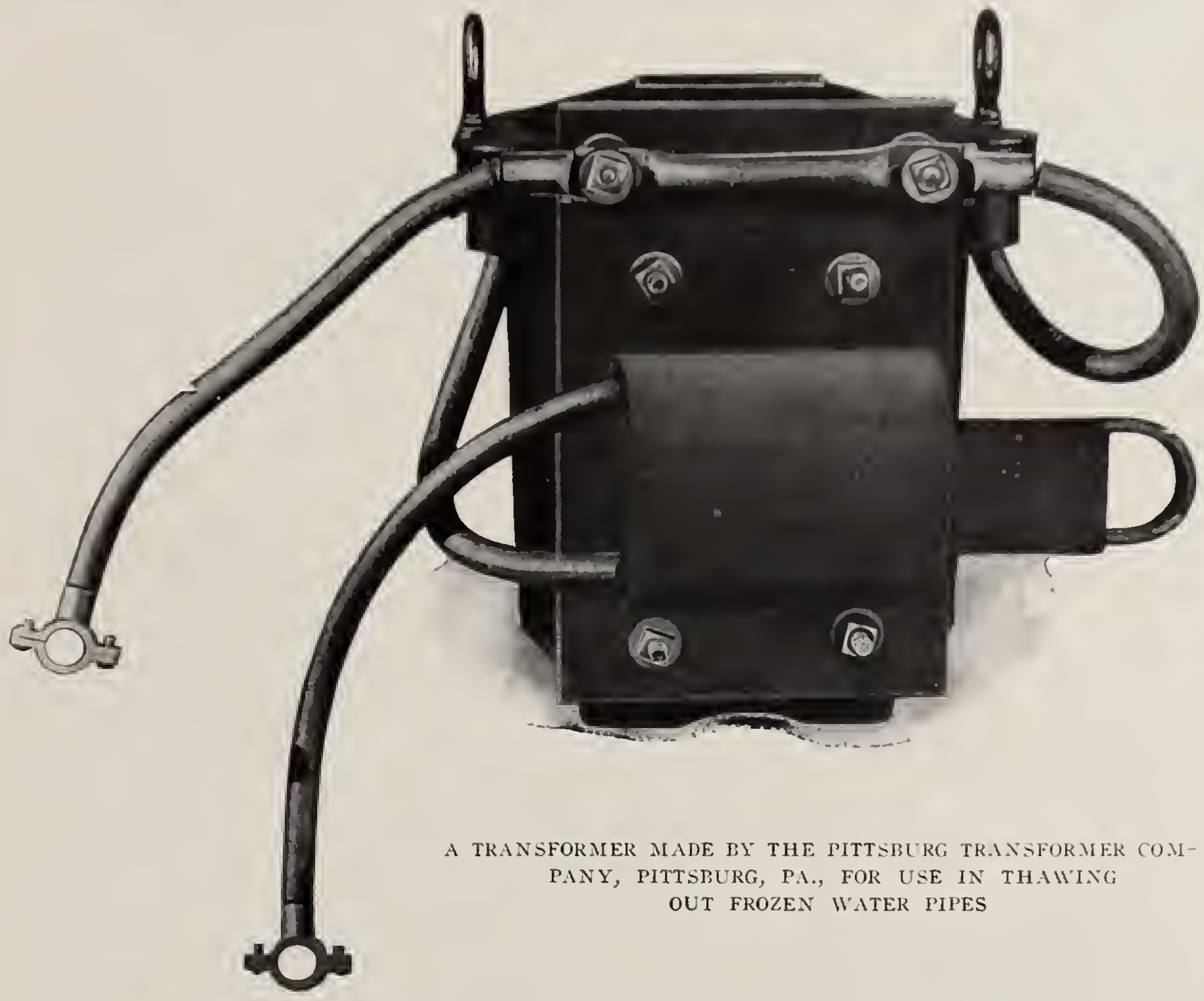
IN connection with what has already appeared in these pages on the subject of thawing out frozen water pipes electrically, it is interesting to note that the Pittsburg Transformer Company, of Pittsburg Pa., also are in the market with a transformer specially designed for work of this character. An illustration of it is given on page 465. The transformer is adapted to operate on any circuit of approximately 1100 or 2200 volts and 60 or 133 cycles, and will deliver a current of 300 amperes continuously, or currents of about 600 amperes for periods of half an hour.

On the back of the transformer are mounted a heat indicator and a choke coil. The former consists of a section of lead pipe, connected in series with the transformer, and the temperature which this assumes is a guide to the heating of the pipe under treatment. The choke coil consists of a few turns of heavy copper bar, with a movable laminated iron core. When this plunger is pushed entirely into the coil, the transformer secondary may be short-circuited, but no more than normal current will flow.

When the transformer is in use, one secondary lead is connected to the pipe inside the house, and the other to a hydrant outdoors, or to a pipe in a neighboring house. In making the primary connections, provision is

made on a porcelain terminal block for altering these to adapt the transformer to the line voltage. It must be protected by a fuse block of 20-ampere capacity for 1100 volts and with a 10-ampere fuse for 2200 volts. A No. 0 wire or cable is used for the secondary connections, with a single-pole switch of 400-ampere capacity.

The hand is kept on the heat indicator, and the plunger is pulled out until the former is hot enough.



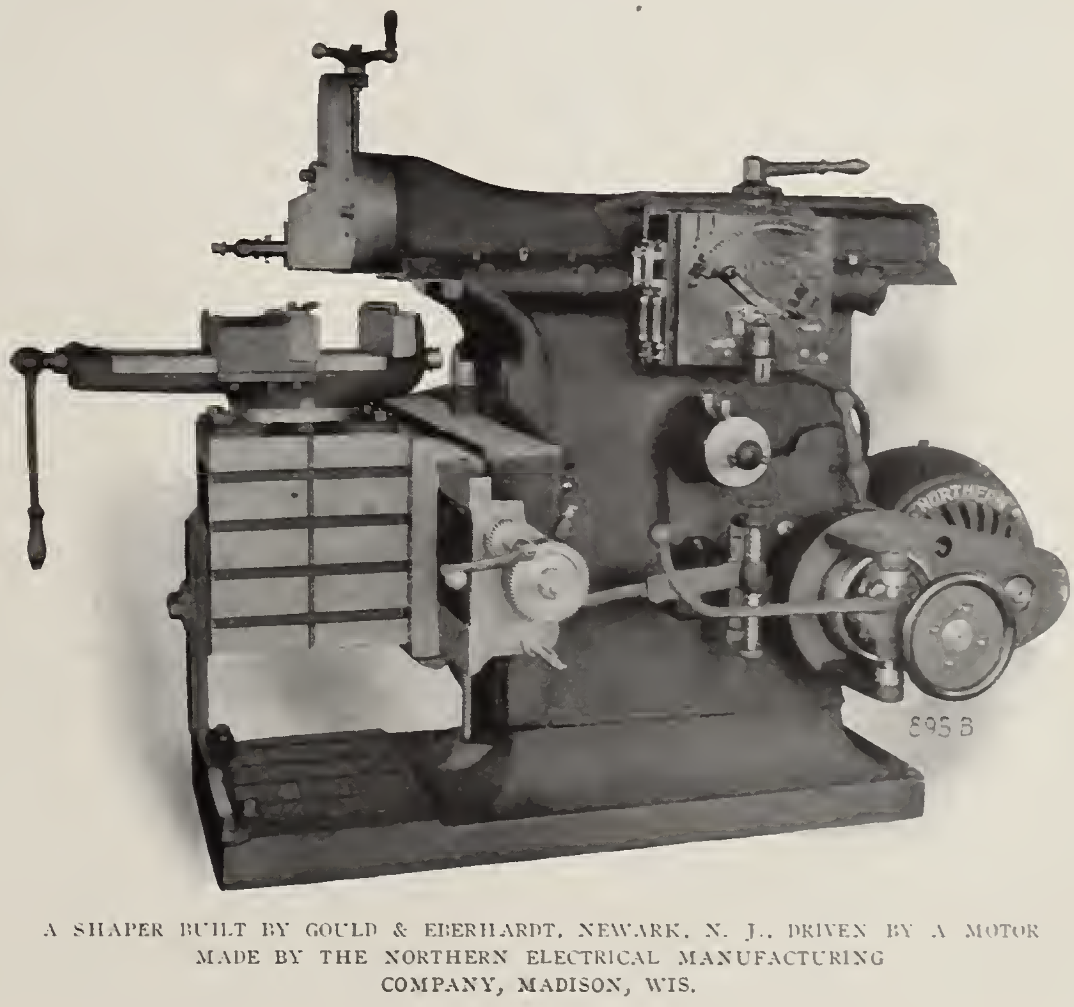
A TRANSFORMER MADE BY THE PITTSBURG TRANSFORMER COMPANY, PITTSBURG, PA., FOR USE IN THAWING OUT FROZEN WATER PIPES

Varnished Cambric Insulation for High-Tension Circuits

A COMPARATIVELY new type of insulation for high-tension circuits and apparatus has lately been introduced in the United States by some of the electric cable manufacturers. It is known as varnished cambric insulation, and consists of strips of oiled linen cambric wound spirally over the conductor in as many layers as may be desired, practically as in the case of oil-saturated paper, varnish being applied between the several layers. The material in appearance and odor closely resembles oil silk and is very adhesive, —so much so that it is claimed for this insulation that it will exclude moisture indefinitely. The insulation has already been employed for high-tension, lead-covered cables in subways where there is danger of the lead becoming impaired through the action of acids or by electrolysis. It is also employed for insulating high-tension conductors behind switchboards and on transformers. Since this insulating material is not detrimentally affected by oil, as is rubber insulation, it may also be used to advantage in place of rubber insulation on the spark-coil circuits of gas engines, automobiles, etc. For the latter use the cambric insulation over the conductor is covered with a braid, to guard against abrasion. The insulation resistance and breaking down test figures of this material are probably not higher than those of oil-saturated paper, and its general reliability and durability yet remain to be determined by actual extensive use in practice. Its cost is about equal to that of oil-saturated paper insulation.

A Variable-Speed Motor-Driven Shaper

THE motor-driven shaper shown in the annexed illustration is of interest because of its compactness and the wide range of speed secured, a variation of 300 to 1600 revolutions per minute of the motor being obtainable. The shaper is of the 24 x 26-inch extension base type, built by Messrs. Gould & Eberhardt, of Newark, N. J., while the motor is one made by the Northern Electrical Manufacturing Company, of Madison, Wis., designed for variable speed on any two-wire, single-voltage circuit. No additional wiring is, therefore, necessary, as is the case with three-wire or multi-voltage systems, and the installation of this motor in plants wired for power distribution to constant-speed, direct-current motors, does not involve any alteration or addition to existing circuits. In connection with the motor-drive illustrated, the speed changes secured in the shaper construction afford a variation in strokes of from 7 to 110 per minute, a wide range of work thus being pos-



A SHAPER BUILT BY GOULD & EBERHARDT, NEWARK, N. J., DRIVEN BY A MOTOR MADE BY THE NORTHERN ELECTRICAL MANUFACTURING COMPANY, MADISON, WIS.

sible. A very convenient feature of the shaper is the clutch, the lever of which may be seen below the line switch end of the controller. This allows the shaper to be stopped or started in any position without stopping the motor. The motor drives the shaper by means of a silent chain. Both the field controller and the line switch are contained in a single device.

Electric Traction from Gas Power

A SOMEWHAT unique departure from established methods in electric traction has recently been undertaken at Warren, Pa. The Warren & Jamestown Street Railway Company is equipping an alternating-current single-phase electric railway system to operate between Warren, Pa., and Jamestown, N. Y., for which power will be supplied by gas engines operating upon natural gas. The equipment is now being constructed by the Westinghouse Companies at East Pittsburg, Pa.

The power station will be located at Stoneham, Pa., 2 miles from Warren. The initial equipment will consist of two Westinghouse gas engines, each of 500 brake horse-power capacity. They will be of the horizontal, single-crank, double-acting type, direct-connected to two 260-K. W. Westinghouse generators, furnishing current at voltage sufficient for direct use upon the high-tension transmission line. The power equipment also comprises a 55-H. P. Westinghouse gas engine for operating an air compressor and exciter unit. Natural gas will be used, furnished by the local distributing company. In this district the gas has a calorific value of about 1000 British thermal units per cubic foot.

Transformer stations, five in number, will be located along the right of way. These will receive the high-tension current from the transmission line and reduce the voltage to such an extent as to render it more suitable for use in single-phase motors. The present motive power equipment will comprise four quadruple sets of Westinghouse single-phase motors, each approximately 50-H. P. capacity. An interesting feature of the system is the arrangement for operating the alternating-current motors upon the direct-current trolley lines within the city limits of the termini.

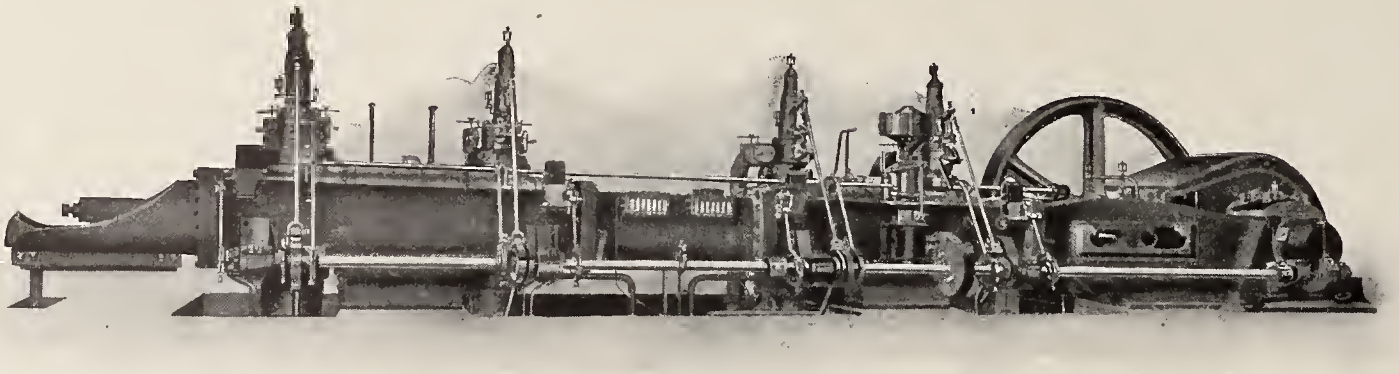
The Warren & Jamestown Street Railway is not a newly organized system, as it has operated part of the present lines for a period of eleven years. Three years ago the company began experimenting with the use of gas power, with sufficient success to influence it in the now exclusive adoption of gas engines for its entire power generation.

Electric Freight Locomotives on the North-Eastern Railway of Great Britain

A NUMBER of electric locomotives for heavy freight service have been built by the British Thomson-Houston Company for use on the electrified section of the North-Eastern Railway's lines around Newcastle-on-Tyne. Each locomotive is capable of handling a 300-ton train on the level and of hauling it at a speed of 14 miles per hour. When working on grades under all conditions of weather, the locomotives are also capable of starting a 150-ton train up a grade of 1 in 27, and of running up this grade at a speed of nine to ten miles per hour.

The locomotives are of the double-truck type, with a central cab and sloping ends. The four motors have a gear ratio of 3.28 to 1, one being mounted on each of the four axles. The control adopted is the Sprague-Thomson-Houston multiple-unit system, and is similar to that used on the passenger trains.

As the locomotives have to operate over sections fitted both with overhead line and third rail, a sliding bow trolley of special design, in addition to the contact shoe, has been provided, automatically reversing itself according to the direction of travel of the locomotive, and also capable of being reversed and lowered when not in use by actuating a worm and wheel device from the cab.



A 500-H. P. TANDEM DOUBLE-ACTING COCKERILL GAS ENGINE, BUILT BY THE WELLMAN-SEAVER-MORGAN COMPANY, CLEVELAND, OHIO

The Cockerill Gas Engine in America

THE Cockerill gas engine, one of the well-known types abroad, especially in large sizes, made at Seraing, Belgium, by the John Cockerill Company, Ltd., is now being built for the American market by the Wellman-Seaver-Morgan Company, of Cleveland, Ohio. As a steam engine competitor for generator driving, it appeals particularly to the power station engineer, as do other designs of large size gas engines; hence, the appended particulars and annexed illustrations which represent a tandem, two-cylinder, 500-H. P. design.

Owing to the considerable differences in temperature occurring in the cylinder, it is necessary to provide for free expansion, and this is obtained by supporting it in a cradle, one end only being attached to the main girders of the engine bed. The pressure at each end of the cylinder is transmitted directly through the girders to the engine frame, as the two heads of each cylinder are connected by through bolts, and the pressure developed in the back end of the cylinder is transmitted through these to the front end.

The pistons are steel castings, in one piece, secured to the piston rod by means of a collar and nut. A special feature of the engine is the water-cooled piston rod nut, which is an additional preventive to premature ignition. The pistons do not bear in the cylinders, but are supported outside the cylinders by cross-heads.

All valves of each cylinder end are operated by a single cam; therefore, in a four-cylinder double-acting gas en-

gine there are only eight cams in all. The valve gear, as may be seen from the cross section on this page, consists of only a few parts in motion, the side shaft *Sh*, driven by the engine shaft, making one revolution to two of the latter, because of the four-cycle principle, carries a cam *C*, for each cylinder end. This cam serves for operating both the inlet and outlet valves, and revolves in the direction indicated by the arrow *l*. When the lobe of the cam begins to act on the roller *r*, the latter and the rod *T* rise, the lever *B* oscillates and its end *b* descends. This movement causes both the mixing valve *M* and air valve *L* to open. The latter, which is fixed to the mixing valve *M*, uncovers the air ports *A*.

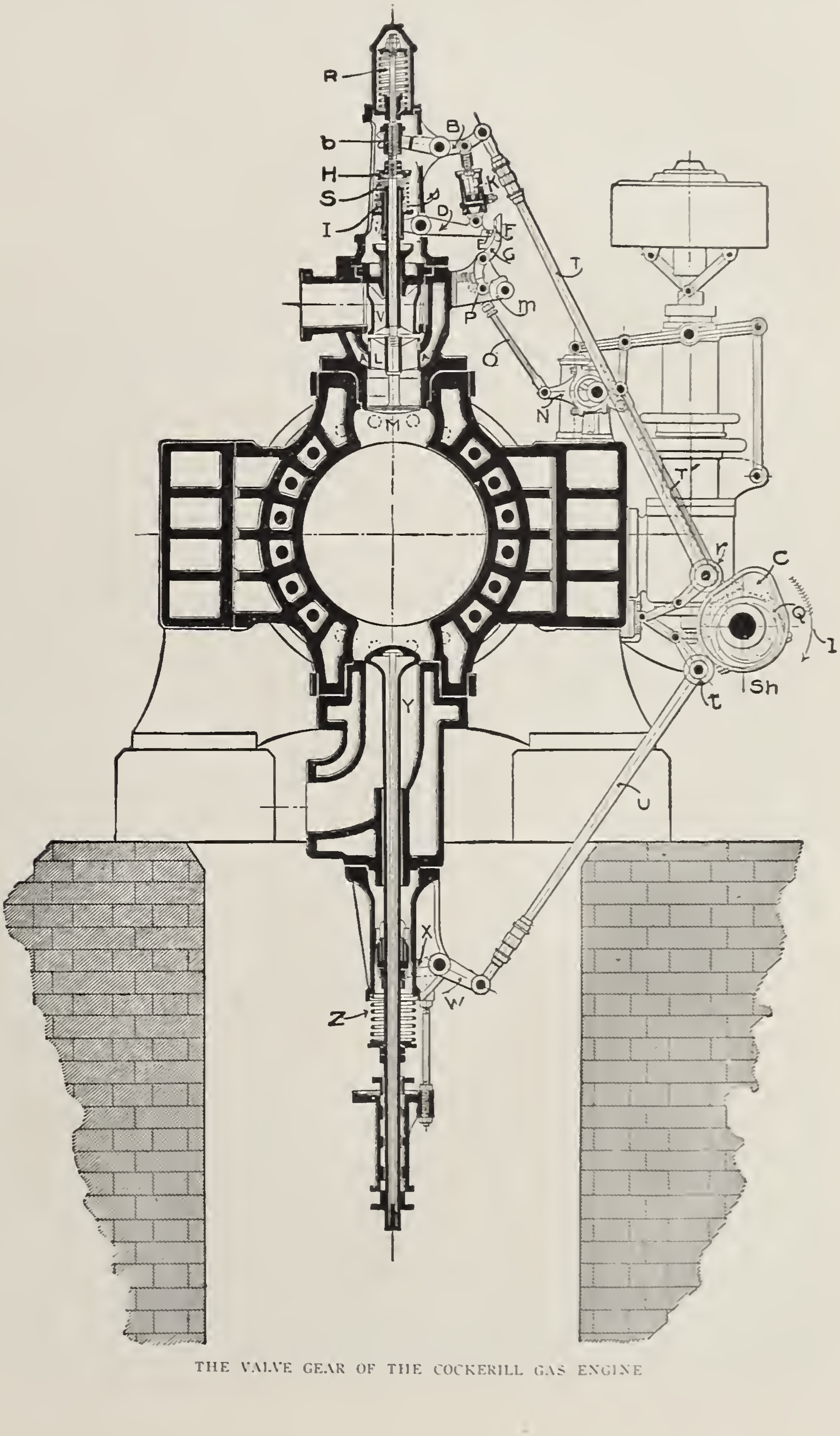
The moment of opening these valves corresponds exactly to the dead center position of the piston at the beginning of the suction stroke. In the first part of the suction stroke air only is therefore drawn in. The double-beat gas valve *V*, concentric with the mixing valve, remains closed. It is operated by the lever *D*, whose outer end *E* engages with the latch *F* of the lever *G*, when the inlet valves are on their seats. During the opening of the mixing valve, the spring cap *H*, fastened to the mixing valve stem, compresses the spring *S*, as the spring cap *I* on the other end is fastened to the hollow stem of the gas valve, which, being blocked by the latch, remains closed. The connection *K* and its parts act as a link of variable length between the levers *B* and *D*.

An eccentric *Q* on the side shaft *Sh* operates a small cam *m* by means of the rod *T*, the oscillating lever *N*, and the rod *O*. The center of oscillation of lever *N* is variable and under the control of the governor, and the effect of the displacement of this center is similar to a change of the length of the rod *O*. The cam *m* operating on the roller *P*, secured to the end of the lever *G*, disengages the latch *F*, at a definite moment predetermined by the governor, and the gas valve *V* opens quickly, the amount of opening being limited by the space between the piston and the bottom of the dash-pot cylinder *K*. The proportions of the lever *B* and *D* are such that the opening of the valves *V* and *M* and also the slide *L* bear a fixed relation with one another.

From the moment of the opening of the gas valve, which corresponds to a certain predetermined position of the piston during the suction stroke, air and gas in proper proportions are admitted so as to give a good mixture. Whatever, therefore, the moment of cut-off may be, the proper quantity of gas and air for a good mixture is admitted. The two valves and the slide remain open until the end of the suction stroke. At this moment, while the roller *r* descends on the lobe of cam *C*, the large spring *R* closes the mixing valve and the air slide, and the link *K* returning to its original length transmits the descending motion of *B* to *D* and closes the gas valve *V*. A small spring *s* is introduced so as to permit the mixing valve *M* to continue its motion and seat itself should the valve *V* touch its seat before *M* can close.

The piston on its return stroke compresses the charge, the inlet and outlet ports of the cylinder being closed; but as the variable quantity of mixture followed a certain volume of air and completed the 100 per cent. of cylinder volume, the best mixture remains close to the igniters located in each cylinder head, and therefore firing is assured even with the smallest load.

A little before the dead center corresponding to the end of the expansion stroke, the lobe of the cam *C* touches the roller *t* and acts by means of the rod *U* and the levers *W* and *X* upon the exhaust valve *Y*, opening it. This



THE VALVE GEAR OF THE COCKERILL GAS ENGINE

A GROUP OF WESTINGHOUSE OFFICIALS PHOTOGRAPHED AT THE RECENT CONVENTION, AT EAST PITTSBURG, OF DISTRICT MANAGERS OF THE WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY. FOR KEY SEE PAGE OPPOSITE

valve remains open during the exhaust stroke (second return stroke of the piston), and is closed on the dead center corresponding to the beginning of the next suction stroke by means of the spring *Z*, which acts at all times to close the valve and presses the roller *t* against the cam *C*.

Kryptol, a New Substance for Electric Heating

WRITING under recent date from Berlin, United States Consul-General F. H. Mason describes a German invention for the production of heat by electricity. The substance heated is a mixture of graphite, carborundum and clay, in the form of a powder of four grades of coarseness.

This powder, or kryptol, as it is called, is placed on an earthenware plate, about 2 feet square, inclosed at its edges in a wooden frame with two carbon electrodes on opposite sides resting upon the plate and connected by insulated wire conductors with a current supply. The powder is placed on the plate to a depth of about an inch, and forms the electrical connection between the electrodes.

When current is applied the powder in the thinner parts of the layer begins to glow, becoming in a few minutes incandescent and giving off heat sufficient to boil water in three or four minutes. The heat may be varied by changing the thickness of the layer, the thick parts remaining comparatively cool and the thinner parts becoming very hot.

With a specially designed crucible, nickle has been smelted by this process in about 6 minutes, and experiments are now being made to determine its adaptability to the annealing and tempering of steel.

The financial report of the Niagara Falls Power Company for the year ended June 30, 1904, shows gross earnings of $1,126,423. Income from other sources amounted to $114,936. The operating expenses for the year were $214,530; charges, taxes, etc., $792,560; improvements and betterments, $74,331, leaving a surplus of $159,938. According to the general balance sheet the real estate, power house, etc., are valued at $15,251,811.

The cost of electricity in Columbus, Ohio, was recently given to the City Council by the superintendent, M. S. Hopkins, of the Columbus Railway & Light Company, as follows: Cost of distribution, 2.7 cents per kilowatt-hour, and of manufacture, 1.243 cents.

Convention of District Managers of the Westinghouse Electric & Manufacturing Company

DURING the week ending November 19 the district managers of the Westinghouse Electric & Manufacturing Company gathered at the works at East Pittsburg and discussed plans and methods for the coming year. These conventions are annual occurrences and are productive of great good, bringing together men from all parts of the United States whose experiences are the natural outgrowth of conditions under which they labor.

Those attending the convention were Calvert Townley, general agent, New York; G. Pantaleoni, general Southwestern manager, St. Louis, Keese, Los Angeles, Cal.; P. N. Jones, Pittsburg, Pa.; D. E. Webster, St. Louis, Mo.; T. P. Gaylord, Chicago, Ill.; L. M. Cargo, Salt Lake City, Utah; J. R. Gordon, Atlanta, Ga.; and T. J. McGill, Minneapolis, Minn.

On the evening of November 16 the management gave a banquet to the visiting managers, at which all of the executive officers of the company were present. A feeling of optimism was evinced throughout the convention regarding the business situation and the prospects of continued prosperity throughout the country.

W. S. Heger, of San Francisco, stated that the outlook on the Pacific

1. E. W. T. Gray, Sales Office, New York.
2. D. E. Manson, Manager, Boston.
3. C. W. Register, Manager, Cincinnati, Ohio.
4. C. B. Humphrey, Manager, Detail and Supply Dept.
5. Chas. A. Terry, Secretary and Attorney, New York.
6. Frank H. Taylor, Second Vice-President.
7. W. S. Heger, Manager, San Francisco, Cal.
8. F. B. H. Payne, Manager, Export Office.
9. G. B. Griffin, Assistant Manager, Detail and Supply Department.
10. C. W. Underwood, Manager, Buffalo.
11. Chas. F. Medbury, Manager, Detroit, Mich.
12. J. E. Johnston, Manager, Dallas.
13. Geo. B. Dusinberre, Manager, Cleveland.
14. R. L. Warner, New England Representative, Boston.
15. L. A. Osborne, Fourth Vice-President, E. Pittsburg, Pa.
16. S. L. Nicholson, Manager, Industrial and Power Department.
17. James C. Bennett, Auditor, East Pittsburg, Pa.
18. M. P. Randolph, Manager, Seattle.
19. Calvert Townley, General Agent, New York.
20. J. R. Gordon, Manager, Atlanta, Ga.
21. C. S. Cook, Manager, Railway and Lighting Dept.
22. W. M. McFarland, Acting Vice-President.
23. C. A. Bragg, Manager, Philadelphia.
24. S. J. Keese, Manager, Los Angeles.
25. W. F. Fowler, Manager, Baltimore.
26. C. F. Scott, Consulting Engineer, East Pittsburg, Pa.
27. Walter Cary, Manager, Sawyer-Man Electric Co., New York.
28. S. H. Anderson, Credit Manager, East Pittsburg, Pa.
29. N. S. Braden, Sales Manager, Canadian Westinghouse Co., Hamilton, Can.
30. F. H. Sheppard, Engineer on Unit Switch Control.
31. P. N. Jones, Manager, Pittsburg, Pa.
32. S. E. Webster, Manager, St. Louis.
33. L. M. Cargo, Manager, Salt Lake City.
34. T. J. McGill, Manager, Minneapolis.
35. G. Pantaleoni, Gen'l Southwestern Manager, St. Louis, Mo.
36. F. F. Rohrer, Correspondent, Main Office, Pittsburg.
37. J. W. Sterns, Mountain Electric Co., Denver.
38. A. Goodby, Correspondent, Main Office, Pittsburg.

DISTRICT MANAGERS AND OTHERS IN ATTENDANCE AT THE RECENT WESTINGHOUSE CONVENTION AT EAST PITTSBURG

Mo.; R. L. Warner, New England agent, Boston, Mass.; E. W. T. Gray, New York; D. E. Manson, Boston, Mass.; W. S. Heger, San Francisco, Cal.; F. B. H. Paine, manager export office, New York; C. W. Underwood, Buffalo, N. Y.; C. F. Medbury, Detroit, Mich; G. B. Dusinberre, Cleveland, O.; W. F. Fowler, Baltimore, Md.; C. A. Bragg, Philadelphia, Pa.; M. P. Randolph, Seattle, Wash.; S. J.

Coast was never better, work being plentiful and money easy. "Mining projects in California are flourishing," he said, "and they appear to have plenty of money behind them. This insures large installations of Pittsburg electrical machinery."

L. M. Cargo, of Salt Lake City, said that the election of President Roosevelt had given a decided impetus to mining development in Utah.

Arizona, Nevada and New Mexico, capital, which prior to that had been timid, being induced to pour money liberally into dormant investments.

J. R. Gordon, of Atlanta, Ga., said: "The South will soon have the greatest boom of its history. For the past two years the cotton crop, the barometer of Southern prosperity, has been phenomenal. Business conditions reveal a greater stability, and the increase of manufacturing in the South is extraordinary. Abundant water power easily available will prove an enormous boon and a producer of business for Pittsburg."

F. H. B. Paine, manager of the export department, said: "The outlook for foreign business has never been more promising for American manufactures, because never before were Europeans more alive to the superiority of American manufacturing methods. Pittsburg apparatus always has the preference because of its superiority."

C. A. Bragg, of Philadelphia, said: "The outlook for general industrial activity was never brighter. While there has been plenty of capital during the past year, timidity over unsettled political conditions prevented its investment. Lack of confidence has disappeared and hopeful buoyancy is observable everywhere."

E. W. T. Gray, of New York, said: "New York suffered severely the past year because of building strikes, but these have subsided, and business has been good there for six months. It is a foregone conclusion that it will be even better, as cheap money is abundant, with no lack of financial support for any legitimate enterprise."

An Edison Company Banquet

THE New York Edison Company tendered a banquet to its agents and inspectors at the Hotel St. Denis, at New York, on Tuesday evening, November 29. Besides the officers of the company more than eighty members of the contract and inspection department were present. The affair was a decided success in every way.

At the speakers' table sat Nicholas F. Brady, Thomas E. Murray, J. W. Lieb, Jr., A. A. Pope, C. A. Littlefield, R. U. Conger, of the Sheldon School of Scientific Salesmanship; and Arthur Williams, who presided.

J. W. LIEB, JR.

In introducing Mr. Lieb, the first speaker of the evening, Mr. Williams said:—

"One's memory readily goes back to the time when all the employees of the company numbered less than half of those present this evening; when the entire territory supplied covered less than 1 square mile, instead of more than 17 square miles, as at present; when there were less than 300 customers, instead of something more than 34,000; when there were no arc lamps, compared with about 23,000 supplied to-day; and to the time when the first horse-power in an electric motor applied to commercial service was connected as a class of our business, which has now grown to more than 90,000 horse-power in motors engaged in every industry in New York City in which mechanical power is used.

"But the greatest part of this extraordinary development has occurred within the past five years—in which years the growth has more than equalled the aggregate growth of the preceding seventeen years of the company's history. Our customers have grown from 16,000 to the present number of nearly 34,000; the incandescent lamps, from 750,000 to 1,600,000; arc lamps, from 10,000 to 23,000; and power, from something less than 40,000 to something in excess of 90,000 horse-power.

"With this growth, it has been necessary to separate and divide our outside forces—referring to only one department of the company's work—into a number of camps or groups of thought and effort, and in this separation the possible tendency has perhaps been away from those conditions which may make most for absolute unity of purpose. Hence, largely, we are here 'getting together' this evening. We shall now have the pleasure of listening to the address of the gentleman who holds the highest office in the gift of American engineers—the presidency of the American Institute of Electrical Engineers—and who is, as well, vice-president of our company. Mr. J. W. Lieb, Jr., needs no formal introduction to this audience."

Mr. Lieb, in his remarks, after some reference to the early history of the lighting industry in the city of New

ARTHUR WILLIAMS

York, alluded to the change in policy of electric light companies and of gas companies also, of vigorous advertising for new business, and the development of novel lines of application for the use of electric current.

He also pointed out that it was well that the business forces of the company—the agents, inspectors and others interested—should meet in the way that has become a recognized feature in the conduct of business, by the technical staffs of the different companies, in order to discuss and compare notes as to the special department of work in which their activities are exercised.

Reference was also made to the important work which those representing the company perform, who come in direct contact with the customer, in making known the new requirements which it may be necessary to meet from time to time, and lines of work which must appeal to the public.

In speaking of the various activities on the part of the commercial branches of the company, Mr. Lieb mentioned

the very successful work performed by the "Bulletin," issued by the advertising department of the company, which has met with pronounced success and had found many imitators among the other lighting corporations.

In introducing Mr. Conger, the toastmaster said:—

"One of the most noticeable features in connection with the World's Fair at St. Louis was the progress shown in educational methods in this country, not only in the education of the child, but in the principles that have been developed for the education of the adult, after entering the working period of his life—the period which has been heretofore largely considered as closed, from an educational standpoint. I refer in this to the correspondence schools, a single one of which, it is claimed, has the striking membership of 700,000, and a staff of not less than 3200 instructors.

"We have with us this evening a gentleman who is thoroughly familiar with this movement, who will address us upon the subject of 'Salesmanship as an Applied Science.' I have pleasure in introducing Mr. R. U. Conger."

Mr. Conger spoke entertainingly of his theories on the science of the salesman. Salesmanship, he declared, was indeed a science, and should be dignified as such. The speaker pointed his remarks with amusing stories and personal anecdotes. He dwelt in detail upon the characteristics which, he asserted, were the prime requisites of scientific salesmanship. Tact, he held, was one of the chief of these. In defining this essential quality of tact, he said:—

"Tact is a product of judgment, intuition and brotherly kindness, and becomes part of a salesman's personality, when these traits have been so cultivated that they enable him to quickly appreciate the circumstances surrounding every situation so adroitly and skillfully that he meets each occasion with perfect poise."

Twenty-Eighth Convention of the National Electric Light Association

PRESIDENT E. H. DAVIS, of the National Electric Light Association, has just returned from a trip to Colorado, where he went for the purpose of deciding upon the meeting place of the twenty-eighth convention of the association. After visiting Denver and Colorado Springs and conferring with a number of Western members, it was decided that the business meetings of the convention be held in Denver for three days and the delegates then be taken to Colorado Springs for the entertainment portion

E. H. DAVIS, PRESIDENT OF THE NATIONAL ELECTRIC LIGHT ASSOCIATION

of the meeting, giving two or three days to sight-seeing and social intercourse. The meeting will be known as the Denver-Colorado Springs convention.

Personal

C. W. Bunnell, Jr., formerly of the Lackawanna Steel Company, has been appointed treasurer of J. G. White & Company, vice Chester Griswold.

C. J. Field, of the Field-Foulks Company, 29 Broadway, New York City, has again entered the field as a consulting engineer, as a separate department from the conduit business of the company.

The Brantford, Ont., Board of Trade has decided to purchase the old Bell homestead on Tutela Heights, for the purpose of turning it into a park, and erecting a memorial in connection with the invention of the telephone there by Prof. A. G. Bell.

In accordance with a new policy of incorporating lectures by prominent engineers as a regular part of the curriculum, the Brooklyn Polytechnic Institute has created a staff of consulting professors on which, thus far, the following gentlemen have been appointed: Dr. F. A. C. Perrine, electric power transmission; Dr. Louis Duncan, electric traction; W. S. Barstow, central station engineering; Charles F. Scott, commercial engineering; and Thomas D. Lockwood, telephony, telegraphy and patent practice. The lectures will be delivered in the evening, and engineers and others desiring to complete their technical education will be enrolled, and at the end of a certain term of attendance will be eligible for a degree.

Charles F. Barth has recently been appointed foreman of the steam turbine department at the West Allis works of the Allis-Chalmers Company. Mr. Barth resigned his position as foreman at the East Pittsburg works of the Westinghouse Machine Company, a position he had occupied for a number of years.

William Maver, Jr., at the request of prominent merchants of Jersey City, N. J., recently investigated and reported upon ways and means of getting rid of overhead wires and poles on the city's principal business streets previous to laying down new asphalt

WM. MAVER, JR.

pavement. Mr. Maver reported that it would be impractical to bury the trolley wires, but that there is no good reason why the electric light and telegraph and telephone companies should not put their wires under ground.

F. Nicholls, vice-president and general manager of the Canadian General Electric Company, and vice-president of the Dominion Iron and Steel Company, says that the period of depression in the iron and steel market of Canada has passed, and that the outlook now is that the Canadian plants will have all they can do to supply the Canadian market. The period of de-

pression has been the worst that Canada has ever experienced, and now the outlook is perhaps better than it has ever been. He also considers the electrical outlook excellent.

DR. PETER COOPER HEWITT

Dr. Peter Cooper Hewitt, of mercury vapor lamp fame, recently returned from Europe and has resumed active experimental work in various lines of electrical research.

R. C. Wright, for several years in charge of the design of special tools and fixtures used in the manufacture of steam turbines at the East Pittsburg works of the Westinghouse Machine Company, has resigned his position with that company to accept similar duties at the Milwaukee works of the Allis-Chalmers Company.

W. A. Nelson, who was appointed superintendent of equipment of the Allis-Chalmers Company, of Chicago, on October 1, 1904, began his services with that company in August, immediately after his resignation became effective as assistant superintendent of the Westinghouse Electric & Manufacturing Company, of Pittsburg, Pa. During his connection of nearly five years with the Westinghouse Company, Mr. Nelson had immediate charge of the plans for the arrangement and location of machinery in the new east machine shop. Prior to his connection with the Pittsburg company, Mr. Nelson had similar duties at the works of the Pratt & Whitney Company, going to Hartford from Fitchburg, where he had been superintendent of the Simonds Rolling Machine Company for a number of years. Mr. Nelson will have duties in connection with all of the works of the Allis-Chalmers Company and his experience admirably qualifies him for making a success in his new undertaking.

C. A. Derby has resigned his position as assistant manager of the Lyon Cypress Lumber Company to join the selling staff of the Allis-Chalmers Company in its saw mill department. Mr. Derby brings to his new position a valuable and varied experience, having been general manager of the F. B. Dubach Lumber Company and previously in the engineering department of the Colorado Fuel & Iron Company, at Pueblo, Col.

Gen. William A. Bancroft, president of the Boston Elevated Railway Company, accompanied by Herbert A. Pasho, division superintendent of the road, left Boston recently for a trip abroad. Their purpose is to inspect the subway and elevated systems of the principal European cities.

J. H. Perkins has resigned the position of general superintendent of the Youngstown, O., Consolidated Gas and Electric Company to become general manager of the Wilkesbarre, Pa., Gas and Electric Company. Mr. Perkins will take up his new responsibilities at once.

J. H. PERKINS

William F. Leggett, who for a number of years was with the Western Electric Company, of New York, and who has had a wide experience in electrical supply work and the publishing of circular matter and the describing of specialties and supplies, is one of the organizers in the Compiling Bureau, 56 Pine street, New York, who are making a business of writing and publishing printed matter for electrical jobbers and manufacturers.

Dr. Louis Bell will give a course of four lectures before the General Electric Engineering Society, Lynn, Mass., during the next few months. The first lecture was delivered at the regular meeting held on Wednesday, November 9. The first three lectures deal with the subject of illumination. The subject for the fourth lecture has not been announced.

DR. LOUIS BELL

E. W. Lloyd, of the Chicago Edison Company, has accepted an appointment from President E. H. Davis, of the National Electric Light Association, to prepare a report on purchased electric power in factories, to be presented at the next annual convention of the association. Mr. Lloyd has already begun work on this report and, as it is a subject of the greatest importance to central stations,—as the power load is rapidly becoming the important part of the business in many localities—it is hoped that managers will take pains to fill in as fully as possible the data blanks sent out by him.

In addition to his several other business interests, Dr. Louis Duncan has become associated also with the staff of the Allis-Chalmers Company, of Milwaukee, having been retained by that company as an expert in electrical patent work in connection with its electrical department, the Bullock Electric Manufacturing Company, of Cincinnati. This connection has only recently been made possible by the retirement of Dr. Duncan from the chair of Electrical Engineering at the Massachusetts Institute of Technology, to which he was appointed in 1892. Dr. Duncan will continue to make his headquarters in New York at 56 Pine street, where he will be closely in touch with the legal and executive offices of the Allis-Chalmers Company.

George Howe, M. E., of New York, is planning a course of lectures to meet the requirements of practical engineers and engineering students who have not had the advantages of a college education. His idea is to equip

such men with a fundamental knowledge of mathematics and the theories of electrical engineering. The course will extend over a period of six months, and consist of two lectures per week. The lecture hall of the Price-Cottle Conservatory of Music, 2105 Seventh avenue, New York City, has been engaged for these lectures. Mr. Howe was formerly instructor of physics at Tulane University and lecturer in electrical engineering in the Young Men's Christian Association night lecture courses, New Orleans, La. His present address is 129 West 117th street, New York City.

Obituary

Max Osterberg, of New York, well known as a consulting electrical engineer, died at Staten Island on October 26. Mr. Osterberg was born at Frankfort-on-the-Main, Germany, in 1869. Coming to the United States, he attended Columbia University and was graduated in two years with the degree of electrical engineer. He was associated with Edison in his X-ray experiments, and since 1896 had been established as consulting and electrical engineer in New York City.

A host of friends and acquaintances will mourn the death of Dr. Thomas M. Drown, president of Lehigh University, and for many years secretary of the American Institute of Mining Engineers, which occurred at Bethlehem, Pa., on November 16. Dr. Drown was born in Philadelphia in 1842. He studied medicine at the University of Pennsylvania and later entered the scientific departments of Yale and Harvard Universities. Going abroad, he studied in the Mining School of Freiberg, Saxony, and in the University of Heidelberg. After his return to this country he became professor of analytical chemistry at Lafayette College, occupying that chair from 1874 to 1881. In 1885 he accepted a similar chair in the Massachusetts Institute of Technology and taught there for ten years, becoming then president of Lehigh University. Dr. Drown was secretary of the American Institute of Mining Engineers from 1873 to 1883, and was elected president of that body in 1897. He was a member of many scientific and technical societies, both here and abroad.

Nelson Stow, the inventor of the flexible shaft, died November 27, at Binghamton, N. Y., aged 76 years. He built and operated the first street car line in that city, but making flexible shafts is the accomplishment for which he has become best known.

Trade News

The Cutler-Hammer Manufacturing Co., of Milwaukee, Wis., manufacturers of motor starters, controllers and rheostats, recently placed an order for a 75 K. W. and a 37.5 K. W. generator with the Northern Electrical Manufacturing Co., of Madison, Wis.

The Westinghouse Electric & Manufacturing Company, through their agents, Messrs. G. & O. Braniff & Co., of Mexico, has been awarded the contract for all the electrical apparatus to be installed at the El Oro Mining & Railway Company, El Oro, Mex. This contract amounts to nearly $100,000.

The Broderick & Bascom Rope Company, of St. Louis, Mo., has been awarded the only grand prize for wire ropes at the St. Louis Exposition.

The Snoqualmie Falls & White River Power Company, of Seattle and Tacoma, Wash., by amended articles of incorporation, has changed its name to the Seattle-Tacoma Power Company and has increased its capitalization to $3,500,000.

The New York & Pennsylvania Company, of Johnsonburg, Pa., has recently placed an order with the Ball Engine Company, of Erie, Pa., for two 1000-H. P. vertical Corliss, cross-compound engines, direct-connected to a generator.

The Canadian Westinghouse Company, Ltd., has sold to the Hamilton Cataract, Power, Light & Traction Company, for use in its Victoria substation at Hamilton, Ont., two motor-generator sets, each consisting of a synchronous motor and a direct-current generator. The motor-generator sets will be of the two-bearing type, the generators delivering direct current at 550 volts to the railway system, and each being rated at 750 K. W. The synchronous motors will take two-phase current at 8000 alternations and 2400 volts and will be rated at 1380 H. P. The excess of capacity in the motors is provided so that they may be used for raising the power factor of the transmission system. Power is taken through lowering transformers from the high-tension transmission line from the De Cew Falls station of the company. These motor-generator sets will be built at the works of the Westinghouse Electric & Manufacturing Company, at East Pittsburg, Pa.

The New England offices of the Allis-Chalmers Company, in Boston, which are now in the Board of Trade Building, and the offices of its electrical department, the Bullock Electric Manufacturing Company, in the Journal Building, were consolidated on December 1 and removed to the State Mutual Building, 50 Congress street. Mr. George H. Berg will be the manager in charge of the consolidated offices.

The Crocker-Wheeler Company, of Ampere, N. J., is offering for sale seven railway generators in the Intramural Electric Railway power plant at the St. Louis Exposition. They will be ready for immediate delivery on January 1. The plant is described in a bulletin sent out by the company.

The Phoenix Iron Works Company, of Meadville, Pa., has received notice from St. Louis that the International Philippine Jury of the Exposition, in its capacity of associate of the board of the Exposition, under the presidency of the Secretary of War, Hon. William H. Taft, has awarded them a gold medal for the compound engine exhibited in the power plant of the Philippine Government Board.

The Electrical Storage Battery Company, Philadelphia, has presented to the Worcester Polytechnic Institute, Worcester, Mass., the entire display made by the company at the exposition in St. Louis. At the close of the exposition the exhibit will be shipped to Worcester and installed at the Institute.

The Goldschmidt Thermit Company, of New York, state that the following companies in the United States have ordered and are using Thermit for welding their rail joints: New York City Railway Company, Brooklyn Heights Railroad Company, Public Service Corporation, of New Jersey (Camden branch), Detroit United Railway Company, Cleveland Electric Railway Company, Chicago City Railway Company, Fitchburg (Mass.) Railway Company, Holyoke (Mass.) Railway Company, Schenectady Railway Company, Birmingham Railway, Light & Power Company, and Hartford Street Railway Company. The number of joints being made by these companies vary from 100 to 1000, and several have placed second orders.

The Mietz & Weiss oil engine, made by August Mietz, of New York City, was awarded a gold medal and special diploma at the St. Louis Exposition. In the past the awards to this engine have been as follows: American Institute, 1897, medal of excellence; Paris Exposition, 1900, highest award for direct-connected oil-engine-generator set; Pan-American Exposition,

1901, gold medal; Charleston Exposition, 1902, gold medal.

The Northern Electrical Manufacturing Company, of Madison, Wis., report the following among their recent sales:—A 200-K. W. generator to the Lee Paper Company, of Vicksburg, Mich., and two 300-K. W. generators to the Consolidated Water Power & Paper Company, of Grand Rapids, Wis. To the latter company were also sold, among others, two large, single-voltage, variable-speed motors.

In the basement of the New England Building, in Cleveland, Ohio, a fire recently occurred which burned off completely the insulation on the outside of the field coils of three Westinghouse 62½-K. W. engine-type generators. Water was turned on these machines for one hour, but, despite this fact, one of the machines was in service at its full load one hour after the water was turned off and another was carrying its full load shortly afterward. At present these two machines are doing the work formerly done by the three.

G. M. Gest, subway contractor, of New York and Cincinnati, has been awarded by the jurors at the St. Louis Exposition the highest award for conduit construction.

The Westinghouse Electric & Manufacturing Company, of Pittsburg, Pa., on Wednesday, November 2, entertained at their works about 600 members of the Iron & Steel Institute, showing them through the various works during the afternoon and giving a banquet to them in the evening. The largest aisle of the company's works was used, its length being one-third of a mile. The part of the aisle set apart for the banquet was beautifully decorated with flags of the United States and Great Britain. Bremer lamps strung from the ceiling and Cooper Hewitt lamps suspended from the sides gave a beautiful lighting effect, the latter light making possible the taking of photographs. The tables were almost hidden beneath the chrysanthemums, roses and other flowers used for ornamentation. A lounging room was provided for the convenience of the guests, where writing materials and souvenir postal cards, showing interior and exterior views of the works, were provided. A unique souvenir was given to each person present at the dinner in the form of an induction motor, small enough to permit of its being carried in the pocket. Sir James Kitson, past president of the British Iron & Steel Institute, thanked the city of Pittsburg on behalf of Andrew Carnegie for the unusual kindnesses shown to the distinguished visiting manufacturers, and Mr. Westinghouse expressed his great pleasure in being honored by the presence of the visitors from abroad.

The Goldschmidt Thermit Company of New York, manufacturers of "Thermit" heating and welding compound, have completed arrangements for the manufacture of thermit in the United States, and are offering the compound at the reduced price of 25 cents a pound. The company are also sending out pamphlets describing the process of heating and welding with thermit, and giving directions for its use.

The W. R. Evans Engineering and Construction Company, Traction Building, Cincinnati, O., has been organized for the purpose of doing an engineering and general contracting business. W. R. Evans is president of the new concern, and his connections with several large propositions insure that the new concern will succeed. The W. R. Evans Company is incorporated, and is well equipped to undertake the construction of railroads, electric light plants, waterworks and other works of similar character.

New Catalogues

An illustrated pamphlet describing steam pumps has been sent out by the A. S. Cameron Steam Pump Works, of New York. Sectional views are given of the steam end and of the water-valve chest, and the different types of pump built for a variety of service are illustrated and described, a table of sizes and weights being given for each type.

Flexible shafting and a variety of drills and grinders for use with the first-named, are illustrated and described in a new bulletin sent out by the Coates Clipper Manufacturing Company, of Worcester, Mass. The shafting is made up of a series of links with ball-and-socket joints, and the illustrations show it in use for a variety of work, in direct connection with a motor or so belted as to allow its working within a limited area. Grinders for lathe attachment are illustrated and also for die-sinkers' and for foundry work. Illustrations of a portable electric drilling outfit and a magnetic hold-on are also given, together with those of a patent screw-driver, angle drive, screw polisher, strapping jack and counter-shafts.

Knife switches are illustrated and described in a new bulletin sent out by the Western Electric Company, of Chicago. The pamphlet describes the many types of knife switches made by the company, illustrations of each being given, with dimensions and drilling plans. In a similar way, fuse posts, terminal lugs, ground detector switches, instrument switches, and panel board switches are treated, wiring diagrams of the ground detector and the instrument switches being also given.

"Producer Gas; Its Uses and Cost," is the subject of a new catalogue sent out by the Wile Power Gas Company, of Rochester, N. Y. The pamphlet describes the advantages of auxiliary gas plants used in connection with gas engines and for heating and furnace work. Illustrations are given of a suction gas producer and an automatic gas producer.

An attractive booklet with the cover title "What I Learned" has been issued by the Standard Welding Company, of Cleveland, Ohio. The pamphlet contains the information regarding electric welding given to a visitor, "The Practical Man," by the company's superintendent during a trip through the works.

A new catalogue illustrating and describing spiral riveted pipe has been issued by the American Spiral Pipe Works, of Chicago, Ill. Illustrations are given of some of the installations and uses of spiral riveted pipe, with the forged steel flanges, fittings, joints and valves used with it. A closed type of feed-water heater made of spiral riveted pipe is illustrated and described. Tables are also given of capacities of centrifugal pumps, weir dam measurements, flow of water through nozzles and pipes, loss of head by friction, with other tables of value in hydraulics.

The St. Lawrence River Power Company, of Massena, N. Y., have issued an attractive little volume illustrating and describing the generation of electricity by water power at Massena. A difference of level of about 50 feet between the St. Lawrence River and the Grasse River, running parallel, is utilized by the company for the driving of generators by means of seven 6000-H. P. turbines. The industries using the current are described, with illustrations of their plants, and the principal features of the city of Massena are also illustrated. The book is of a high order typographically and the engravings are well executed.

Advance sheets of a new bulletin illustrating alternating-current motors and generators and rotary converters have been sent out by the Electric Machinery Company, of Minneapolis,

Minn. The list comprises generators and synchronous motors of the revolving-field type, belted and direct-connected generators of the revolving-field type for water-wheel connection and 60 and 25-cycle rotary converters of a capacity up to 1000 K. W.

Turbines and centrifugal pumps are illustrated and described in a new catalogue issued by the I. P. Morris Company, of Philadelphia, Pa. The pamphlet is devoted mainly to a description of some of the company's installations of turbines and heavy centrifugal pumping machinery, illustrations of the individual machines and of the plant and cross sections of the latter being given in each case.

"Traction Development" is the title of a pamphlet recently issued by the Transit Finance Company, of Philadelphia. The purpose of the booklet is to educate investors regarding the upward tendency of traction securities, and it therefore deals with the mechanical and electrical considerations involved in the building of the electric road, the cost of construction, estimates of earnings, and their bearing on the quality and value of electric traction securities.

Barometric condensers, made by the Alberger Condenser Company, of New York, are illustrated and described in a new catalogue sent out by the company. The pamphlet also contains illustrations and descriptive matter of single and two-stage dry vacuum pumps, Corliss circulating pumps, centrifugal circulating pumps, mechanical and natural draft cooling towers, exhaust relief valves, exhaust entrainers and surface condensers.

A pamphlet containing a list of second-hand wood-working machinery has been sent out by the J. A. Fay & Egan Company, of Cincinnati, Ohio. The list comprises blind and door machinery, chamfer-cutting machines, lathes, matchers, molders, mortisers, sanders, saws, surfacers, tenoners, dovetailers and a number of miscellaneous tools. A list of iron-working tools is also given, comprising lathes, grinders, turret lathes and milling machines. A new gang dovetailer, a band rip saw and a band scroll saw made by the company are illustrated and described in the pamphlet.

A new pamphlet of the Joseph Dixon Crucible Company, of Jersey City, N. J., treats of the company's lubricating graphites and graphite lubricants. Lubricant for every purpose is listed in this booklet, the functions of each being described. A description of the company's graphite pipe joint compound is also given.

Using Roentgen Rays in Cable Factories

A PORTABLE apparatus for the detection by means of Roentgen rays of impurities, air bubbles, and the like, in cable insulation, has been recently placed on the market by the Elektricitaets Gesellschaft Sanitas, of Berlin.

It consists of a case mounted on an iron frame on wheels and containing the induction coil and condenser. The whole can be readily moved about by means of the handles. One side of the case is removable, to permit the interrupter and the motor working it to be easily inspected. A switch panel is also fitted containing two fuses, adjustable resistances for varying speed of the interrupter motor, and for altering the primary current and main switches for the motor and for the induction coil.

A framework is fixed over the top of the case and carries two roller guides for the cable under test. Beneath these guides the Roentgen tube is held in a wooden clamp, and above them an adjustable fluorescent screen is fixed. As the cable is drawn past, any irregularities in its structure are reproduced on the screen. By enclosing the screen in a light-proof covering the test can be readily carried out without darkening the room in any way.

Annual Report of the Western Union Telegraph Company

THE annual report of the president of the Western Union Telegraph Company makes the following comparison of business done by the company in 1903 and 1904:—

	Year Ended June 30, 1903	Year Ended June 30, 1904
Revenues	$29,167,686.80	$29,249 390.44
Expenses	20,953,215.07	21,361,915.46
Net revenue	$8,214,471.73	$7,887,474 98
Interest on bonds...	1,077,700.00	1,157,700.00
Profits	$7,136,771.73	$6,729,774.98
Appropriated for dividends	4,868,050.00	4,868,071.25
Surplus	$2,268,721.73	$1,861,703 73

The statement of expenses for the year is given in detail as follows:—

Operating and general expenses, including taxes	$15,736,592.24
Rentals of leased lines..................	1,600,885.06
Maintenance and reconstruction of lines	3,627,196.06
Equipment of offices and wires........	397,242.10
Total expenses	$21,361,915.46

Statistics for the year 1866 give the miles of poles and cables at 37,380, the miles of wire at 75,686 and the number of offices at 2250. For 1867 the same items are, respectively, 46,270; 85,291; and 2565. The number of messages given for the latter year is 5,879,282, the receipts were $6,568,925, the expenses were $3,944,005 and the net revenue $2,624,919

For 1904 the miles of poles and cables are 199,350; the miles of wire 1,155,405; number of offices, 23,458; number of messages, not including those sent over leased wires or under railroad contracts, 67,903,973; receipts, $29,249,390; expenses, $21,361,915, and net revenue, $7,887,474.

Telephones for Panama

ACCORDING to "The Telephone Magazine," E. T. Lefevre, of the city of Panama, Republic of Panama, has obtained from the municipal council a franchise by which he can establish, maintain in operation and exploit during twenty-five years, a system of telephonic communication in the city and suburbs.

This franchise concedes the right to use the streets and public places for installing central stations, aerial or underground cable, lines, poles, etc., and all that is necessary to operate a first-class, modern plant. The enterprise which he will establish will be exempt during the twenty-five years of the franchise from all municipal taxes.

Up to the present time Mr. Lefevre has not made any arrangement for the organization of a company or for the buying of material. It is his purpose, however, to put in operation a central energy system, or recommend to the company which may be organized the installation of such a system.

It is his expectation that, within a short time, it will be possible to install in the city alone about 1000 instruments. He also expects to have franchises for other important towns of the Republic of Panama within a short time.

At the laying of the cornerstone of the new Orange Methodist Church, in Orange, N. J., recently, a photograph of Thomas A. Edison as Orange's leading citizen and an original phonograph record cylinder on which was the music of "Lead Kindly Light," together with a set of battery plates from the inventor's new storage battery, were placed in the copper box with newspapers and other articles of interest.

When the Pennsylvania Railroad Company completes its arrangements for its vast terminal facilities in New York City the electric locomotive will draw its trains through the Hudson River Tunnel.

In London there is one telephone to 60 families. In New York there is one to 12.

Electrical Energy Direct from Coal

By J. WRIGHT

THE successful solution of the problem of how to obtain electrical energy direct from coal would go a long way towards revolutionizing existing methods in the engineering and scientific world generally, in that a more or less immediate application of enormous sources of

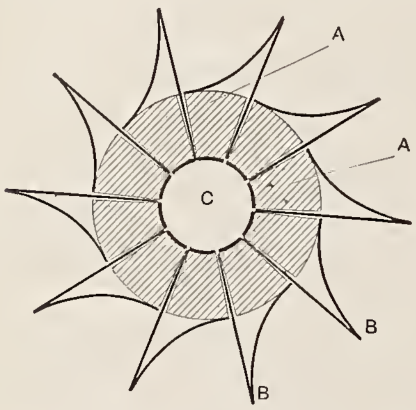


FIG. I.— CLAMOND'S THERMOPILE

power, without the intervention of the present cumbersome boiler, engine and dynamo, would thus be rendered possible, and solve many of the existing problems which are on the eve of solution, such, for instance, as aerial navigation.

With existing methods for the production of electrical energy on a commercial scale, by means of high-grade boilers and high-efficiency steam engines and dynamos, only about 6 per cent. of the latent energy stored in coal is available at the terminals of the generator. Any system, therefore, which would tend to render this enormous store of energy immediately available, even to the extent of 50 or 60 per cent., would be exceedingly welcome to the engineer and the scientist, and it is with the object of summarizing what has already been done in this connection, and in what direction such minor successes point for a final solution, that the following paragraphs have been penned.

One of the earliest discoveries in connection with this problem was that made by an engine-driver named Seghill in 1840, which culminated in the construction of Sir William G. Armstrong's hydro-electric machine. Seghill elicited the fact that steam, issuing under pressure from the safety-valve of a boiler, becomes electrified. Armstrong and Pattinson investigated the phenomenon and found that it was due to the friction of the minute particles of water, or condensed steam, against the walls of the passage providing the exit, and on this fact was based the construction of the historical machine which consisted of a boiler and furnace mounted on four strong glass insulating pillars and provided with the usual gauges and steam dome, from which latter the outlet pipes were led into a species of iron chamber for the purpose of partially condensing the steam prior to its liberation, it being essential to the success of the device that the escaping steam should carry as much moisture as possible. With a similar object in view, and also to increase the frictional resistance offered to its passage, Armstrong constructed a series of wooden nozzles, in passing through which the steam was caused to impinge upon a disc and pass around the edge of the latter. In front of the nozzles was placed a series of metal points forming a collecting comb, against which the particles of condensed vapor were projected. This comb was carried by a second insulating pillar, which served as the positive terminal of the apparatus, whilst the boiler constituted the negative terminal.

With this machine Sir William Armstrong succeeded in producing large quantities of static electricity, which, in discharging from pole to pole, developed sparks from 5 to 6 feet long. The hydro-electric machine proved, however, to be impracticable and inefficient for the production of electrical energy from coal on a commercial scale and, as a natural consequence, the discovery has never overstepped the boundary imposed by the term "interesting scientific experiment."

A still earlier method of generating an electric current from the heat of combustion of coal is by what are known as thermopiles. As far back as 1822 Seebeck discovered that a current is produced in a closed electric circuit by heating the point of contact of two dissimilar metals forming part of that circuit. The electromotive force of the current produced in each couple is very small, and depends upon the two metals selected to form the thermo-electric couple. As the result of his experiments, Seebeck compiled the following table of metals, arranged in their thermo-electric order, each metal being electro-positive to those which follow it in the list:—

(+) Bismuth	Copper	Silver
Nickel	Lead	Zinc
Cobalt	Tin	Iron
Platinum	Gold	Arsenic
		Antimony (—)

If any two metals be selected from this list and a good electro-mechanical junction be effected between them, the heating of this junction will produce a flow of current from the electro-positive metal to the electro-negative through the heated junction. Alloys also are available for the production of thermo-electric currents, and Seebeck compiled a second list of metals and their combinations, in thermo-electric order, as follows:—

(+) Bismuth	3 Bismuth, 1 Lead
Lead	1 Antimony, 1 Copper
Tin	1 Antimony, 3 Copper
1 Bismuth, 3 Tin	1 Antimony, 3 Lead
1 Bismuth, 3 Lead	1 Antimony, 3 Tin
Platinum	Steel (cast)
1 Bismuth, 1 Lead	Steel (rod)
Gold	3 Bismuth, 1 Tin
Silver	1 Bismuth, 3 Antimony
1 Bismuth, 1 Tin	Antimony
Zinc	1 Antimony, 1 Tin
	3 Antimony, 1 Zinc (—)

Seebeck's discovery led to a number of praiseworthy attempts to apply the thermo-electric principle to the practical generation of electrical energy on

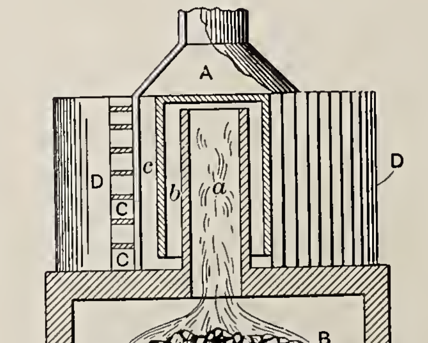


FIG. 2.—AN IMPROVED CLAMOND PILE

a commercial scale. The resulting devices are known as thermopiles, and consist, in the main, of a number of thermo-electric couples, connected together electrically in order to combine their resulting electromotive forces, and constructed physically in such a manner as to facilitate the simultaneous heating of all the junctions from a central source.

One of the earliest thermopiles was

that of Markus, constructed in 1864-65, which gained a prize from the Vienna Society for the Promotion of Science. The positive metal was an alloy, consisting of twelve parts of antimony, five parts of zinc and one part of bismuth, and each electrode consisted of three strips fastened together by screws. The negative electrode, on the other hand, was an alloy consisting of ten parts of copper and six parts of zinc and nickel, and was made in the shape of a rectangular bar. A number of these elements were connected together after the manner of lattice-work, and placed in two rows, sloping together at their apices, and forming a structure not unlike the roof of a house. The ridge of the "roof" was constituted by an iron bar, to which the junctions were severally attached by means of screws passing through the bar; mica plates and bushings were interposed between the couples and the bar in order to insulate them, and heat was applied to the junctions through the medium of the iron bar itself, which was supplied with heat from a convenient source. The junctions between neighboring couples were effected at the lower edges of the slopes and immersed in cold water, in order to make the difference in temperature between the two sets of junctions more marked. The electromotive force of each of these couples was equivalent to one-twentieth of that of a Daniell cell.

Clamond's original thermopile was constructed in cylindrical form, the principle of construction being represented in Fig. 1, which shows a transverse section through one set of couples. *A A* are sector-shaped blocks of an alloy of zinc and antimony, arranged in a circle, and to their inner and outer surfaces are attached the sheet-iron plates, *B B*, these latter being extended, as shown, beyond the normal periphery of the circle, in order to provide an increased surface for the radiation of heat, thereby keeping the outer junctions cool. Several sets of electrodes thus constituted were placed one above the other and separated by insulating pieces. The central tube or chimney, *C*, thus formed was lined with asbestos cement, and an earthenware tube, pierced with a number of holes to serve as a multiple jet gas burner, was introduced, and supplied with gas from a convenient source.

In 1879 an improved form of Clamond pile was described by Th. Du Moncel, which was capable of being energized by the heat from a specially constructed coke furnace. It is represented in sectional elevation in Fig. 2, and consists of a zigzag flue, *a b c*, made up of three concentric cylinders, communicating with one another at the top and bottom, as shown. The last of these cylinders, *c*, leads into a chimney, *A*, whilst the first receives the hot gases resulting from the combustion of coke in the furnace, *B*; the heated gases of combustion are thus compelled to pass three times over the inner surfaces of the cylinders before finding an exit. *C C* are sheet-iron elements arranged immediately out-

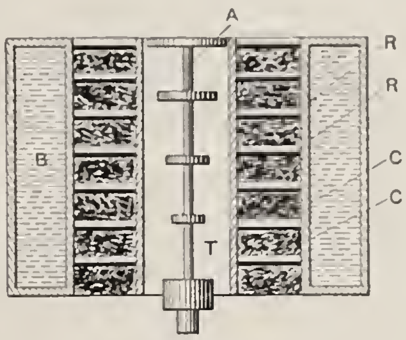


FIG. 3.—COX'S THERMOPILE

side the cylinder, *c*, whilst *D D* are vertical copper plates arranged radially, in order to secure a large surface for cooling the outer junctions by radiation. Cazin records that two such thermopiles, 98 inches high and 39 inches in diameter, each comprising 30 sets of 100 couples each, were capable of generating current at an electromotive force of 109 volts and offered an internal resistance of 15.5 ohms. The consumption of coke to achieve this result is stated to have been 22 pounds per hour.

Nöe and Hauck also constructed thermopiles on a circular plan; in fact, Clamond's original pile seems to have set the fashion in this respect, and a very convenient form for heating is thereby procured.

Cox's thermopile is one of the most modern productions in this field, and was, until a short time ago, obtainable

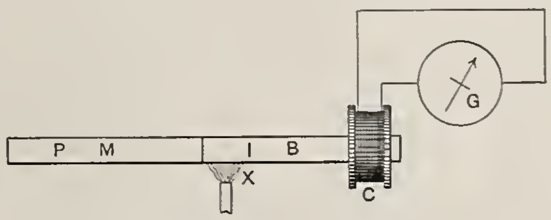


FIG. 4.—THE PRINCIPLE OF TESLA'S PYRO-MAGNETIC GENERATOR

in Great Britain, but it is understood that its manufacture has been discontinued. A diagrammatic view of its internal construction is represented in Fig. 3, where *R R* are the thermocouples, arranged in annular form, and separated from one another by insulating pieces, *C C*. The central tube, *T*, is lined with fireclay and heated by a Bunsen burner, the flame from which is spread outwards against the walls of the tube by a special device, *A*. *B* is a water-jacket, provided with inlet and outlet pipes, and so arranged, immediately outside the outer junctions, as to keep them cool by the circulation of cold water whilst the pile is active. The stock patterns of this pile had electromotive forces of 3, 3.5, 4.5, 5 and 8.5 volts, and were capable of generating 4, 4.5, 3.5, 3.2 and 2.5 amperes, respectively.

There are several other types of thermopile, all of which, however, are similar in principle to the three already described, and which will serve as examples of their kind.

To sum up, the thermopile is an extremely inefficient device for the production of electrical energy from heat, and possesses also several inherent defects, which render it unsuitable for any but a few special requirements. Chief among the drawbacks of this type of generator are, firstly, its necessarily high internal resistance, owing to the fact that the hot and cool junctions must be separated by an appreciable expanse of metal; secondly, the difficulty of preserving, for any length of time, good electrical conductivity at the junction, owing to oxidation and other causes; and thirdly, the extremely rapid depreciation of the pile, owing to the sudden extremes of temperature to which its parts are subjected, and which give rise to consequent expansion and contraction of the metal, tending to loosen all joints and, in time, prove the destruction of the whole pile.

Having thus briefly considered the subject of thermopiles, let us next proceed to discuss what are known as pyromagnetic generators of electrical energy. At the beginning of the seventeenth century Dr. William Gilbert elicited the fact that natural magnet (loadstone) or a magnetized iron bar, if subjected to a red heat, loses its magnetic properties. On this discovery one or two devices for the generation of electrical energy have been based, and I will first proceed to deal with the work of Nikola Tesla in this direction. Tesla based the design of his pyro-magnetic generator on the above fundamental principle, and also on a second law, which is to the effect that if any conducting body (electrically considered) be subjected to a varying magnetic influence, electrical energy will be developed in that body. These two basic principles may be ably demonstrated by a simple experiment, suggested, I believe, by Tesla himself. Referring to Fig. 4, if a permanent bar magnet, *P M*, be placed end on to, and in contact with, an iron bar, *I B*, in such manner as to magnetize the latter by contact, and a coil, *C*, be wound round the outer extremity of *I B*, and connected in circuit with a gal-

vanometer, *G*, as shown, then on heating *I B* at the point *X*, by means of a suitable flame, until it becomes a bright orange-red, indicating a temperature of about 600 degrees C., the magnetism in *I B* will disappear and, in its passage, give rise to a current of electricity in the coil, *C*, which will be duly recorded by a deflection of the galvanometer needle. On removing

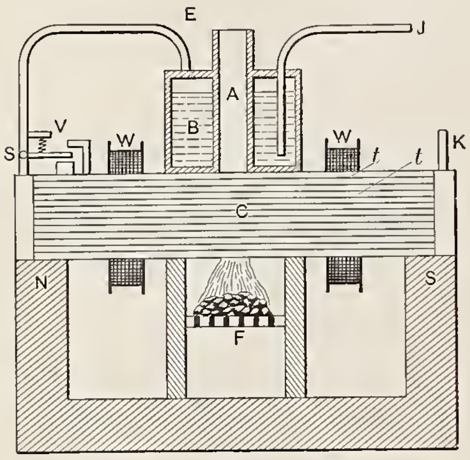


FIG. 5.—TESLA'S GENERATOR

the source of heat and allowing *I B* to cool, its magnetic properties will again return, with the production of a second current in *C*, which, however, will be flowing in an opposite direction to the first, as indicated by the galvanometer needle, which will swing over in the opposite direction.

Tesla's suggestion for the application of this principle in practice is shown in Fig. 5, where *N S* represents a powerful magnet, the poles of which are bridged by a rectangular iron casing, *C*, containing a number of iron tubes, *t t*, the whole forming an armature or "keeper" to the magnet *N S*. Around the casing are wound coils of insulated wire, *W W*, in which the resultant electrical energy is to be generated. The armature passes through the center of a specially constructed furnace, *F*, provided with a chimney, *A*, and surmounted by a boiler, *B*. A water inlet pipe, *J*, and steam outlet, *E*, are fitted to the boiler, the steam outlet being led round to the common entrance of all the tubes, *t*, as shown. An exhaust pipe, *K*, is provided at the opposite extremity of the armature. *V* is a steam valve, actuated by a spring-controlled lever, *S*, which, when the armature is magnetically active, is attracted downwards and closes the valve. On the center of the armature becoming heated by the furnace, it loses its magnetism, with a consequent production of electrical energy in the coils, *W*, and the release of the lever, *S*, which is drawn up by its spring, opening the steam valve, and allowing steam to enter the armature. The steam exercises a cooling effect on the latter, with the result that its magnetism returns, a current is again produced in *W W*, and the steam is automatically cut off, as before, and so the cycle of operations goes on. The main drawback to this and other types of pyro-magnetic generator is their necessarily sluggish action, a perceptible interval being necessary to allow the active portion of the magnetic circuit to assume its extremes of temperature. In 1887 Edison turned his attention to this type of generator and succeeded in producing a machine of 1500 pounds weight which was capable of developing electrical energy to the extent of 3-H. P. The principle of Edison's generator is represented in Fig. 6, where *M M* are a number of horizontal magnets, arranged radially with their inner poles towards a center vertical shaft, *A*. On the latter, and so mounted as to revolve with it, is fixed an armature, consisting of a number of vertical iron tubes, *t*, 1-200-inch in thickness, and mounted, top and bottom, in thick iron discs, *D D*. Each of the armature tubes is wound with an insulated wire coil, the ends of which are led to a commutating device (not shown) by which the resulting currents may be rendered unidirectional. *S S* are refractory earthenware or fireclay screens, arranged, one above, and the other below, a segmental portion of the tubes, *t*, so as to screen some of them from the heating effects of the coal furnace, *F*. On rotating the armature, those tubes which are open to the furnace lose the magnetism which they receive by induction from the magnets, *M*, and a current is generated in the coils surrounding them; on passing over to a position in which they are screened by the segments, *S S*, they become cool, with the result that their magnetism returns, and a second current is generated in the coils.

Edison's device possesses several defects; firstly, it is heavy, compared with the output of energy; secondly, its iron tube armature, owing to the fragile construction necessitated, speedily disintegrates; and, thirdly, it can be run only at a slow speed, about 120 revolutions per minute. A generator on a similar principle to the foregoing has also been designed by M. Menges, of Holland, the necessary heat energy being supplied by a number of gas jets.

All the devices so far described for the production of electrical energy from coal have depended on a primary conversion of that latent energy into heat by direct combustion in a furnace. This, in itself, implies considerable waste, in that many of the elementary bodies contained in the coal are either consumed or pass off in the form of vapor or gas without yielding a proportionate return as heat energy. We must look, therefore, for a more direct conversion than that represented by direct combustion pure and simple.

Volta's valuable discovery at the close of the eighteenth century which resulted in the evolution of the ubiquitous primary battery, opened up a wide field for scientific research in connection with the production of electrical energy by chemical action. The element mainly concerned in the production of electrical energy by voltaic action is zinc, and this metal is, unfortunately for the success of the problem, far less plentiful than coal, so that, to contrast the two substances from the point of view of commercial economy in the production of current by known methods, shows a decided balance in favor of coal and the steam engine. With the object of overcoming this drawback many attempts have been made to substitute carbon, the predominant partner in the composition of coal, as the element to undergo combustion in a voltaic cell.

Here we are met by difficulties of a grave nature. Coal per se is a poor conductor of electricity, but is readily converted into a good one in the shape of coke, which is almost all carbon, and, moreover, gives up valuable by-products in the process of conversion. Then, again, it is essential to the success of a voltaic cell that the positive, or consumed electrode, should be strongly electro-positive, and this, in point of fact, carbon is not, being rather the reverse, and electro-negative to all but a few elements, thus

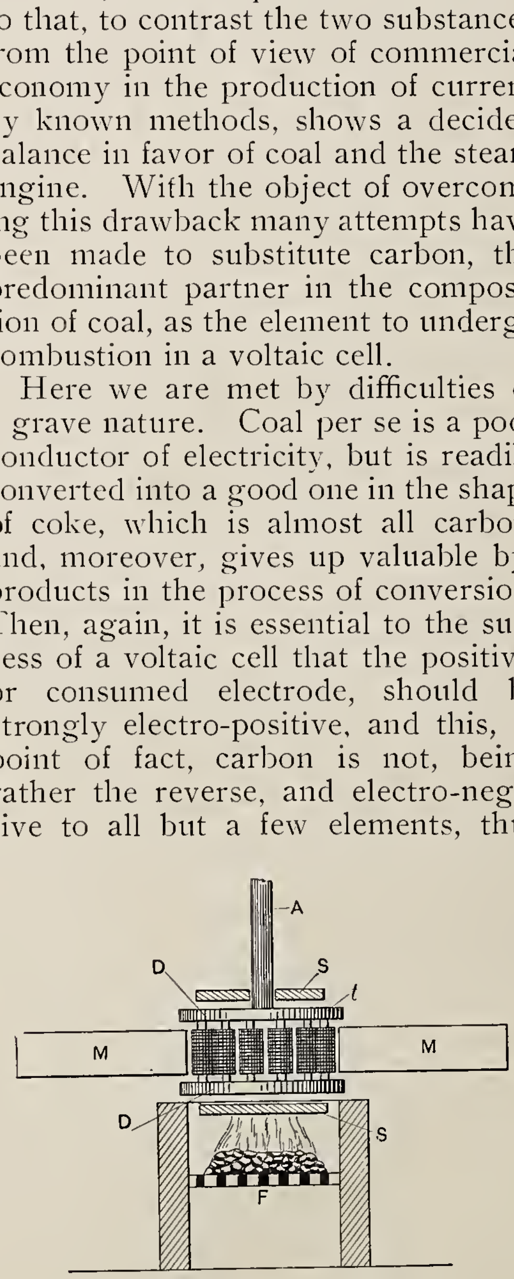


FIG. 6.—EDISON'S GENERATOR

rendering the available range for the selection of a suitable negative very limited in character. To crown all, carbon is insoluble in all ordinary solutions, thus introducing another difficulty,—the selection of an electrolyte.

Despite these various drawbacks, many attempts have been made to employ carbon as a positive electrode in a battery for the generation of electrical energy by voltaic action, and the writer will proceed to deal with one or

two of the most noteworthy methods.

C. J. Reed's process, which was first published in 1896, is represented in Fig. 7, where *R* is a retort, mounted upon a suitable furnace, *F*, and containing the separate ingredients *S* and *C*, consisting of sulphur and carbon, respectively. *P* is a small mass of pebbles, over which water is allowed to trickle from a supply tube, *T*. The furnace *F* is fed with sulphur, which, by its combustion, is converted into sulphur dioxide gas; this passes out at the exit flue and is collected by solution in water, forming sulphurous acid. The heat thus generated causes the sulphur *S* to vaporize, and the vapor, in passing over the mass of heated carbon *C* is converted into bisulphide of carbon. Simultaneously, the heat of the furnace *F* produces steam at the point *P*, and this steam, mingling with the carbon bisulphide vapor, forms sulphuretted hydrogen and carbon dioxide gases. These two mixed gases also pass over into water, which readily dissolves the sulphuretted hydrogen, but the carbon dioxide sparingly,—in such small quantity as to render it negligible. Sulphurous acid and sulphuretted hydrogen solution, thus formed, are placed in a two-compartment vessel, separated by a porous partition which permits diffusion. As electrodes, a carbon plate is placed in each liquid, and the resulting voltaic action produces water and sulphur, giving rise to an electromotive force of about 0.36 volt. Unfortunately, the diffusion, and consequent combination of the two liquids, goes on all the while, whether the external circuit be open or closed; there is thus considerable waste, and the electromotive force being very low, this arrangement has not proved itself commercially practicable.

Another device, the introduction of which at about the same time created quite a furore in scientific circles, is that of Jacques, and is known as the Jacques cell. It is represented in diagrammatic section by Fig. 8, and consists of a furnace, *F*, over which is mounted an iron retort, *R*, which constitutes the negative electrode of the battery. Placed axially in this retort, but insulated from it by the lid, *L*, is the carbon, or positive electrode, *C*, immersed in a mass of fused caustic soda, *S*, contained in the retort *R*, and maintained in a state of fusion by *F*. *P* is an inlet pipe for atmospheric air, under pressure, from a pump, the stream of air being distributed under the lower extremity of the carbon electrode by a perforated head, *H*, similar to the rose of a watering-pot.

The action claimed for this type of generator is as follows:—The oxygen of the air, in the presence of the fused caustic soda, unites with the carbon to form carbon dioxide, which passes off from the retort in the shape of gas, whilst the electrolyte remains unchanged, and can, in consequence, be used indefinitely. An electromotive force of one volt is produced at the terminals of the cell. In practice, carbonate of soda is formed in no inconsiderable quantity, and this, together with other impurities emanating from the carbon, tends to destroy the utility of the caustic soda in course of time. Moreover, an extraneous source of heat, the furnace *F*, is required to work the cell, and also an auxiliary pump for the air supply, both of which items considerably detract from the economical working of the apparatus.

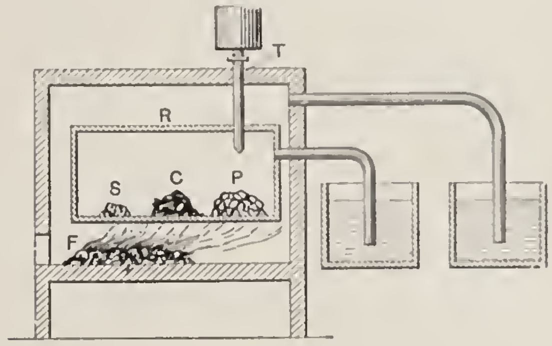


FIG. 7.—REED'S PROCESS

Blumenberg's cell is very similar to the foregoing in its construction and the principle on which it depends for the generation of an electric current. The carbon and containing retort of iron or copper are arranged as in the previous apparatus, whilst the caustic soda is mixed with lime and cryolite. The air-pump of Jacques' cell is rendered unnecessary by the addition of an annular boiler which surrounds the retort and is heated by the same furnace. The steam generated is led into the electrolyte and, by its decomposition into its constituent elements, hydrogen and oxygen, supplies the place of the air in the former device.

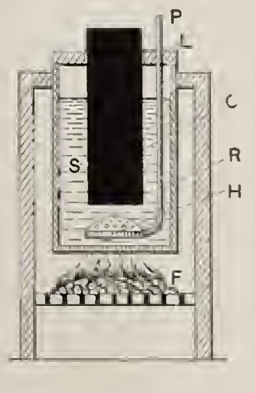


FIG. 8.—THE JACQUES CELL

Whilst on the subject of voltaic action, we must not forget the valuable services rendered by Sir William Grove in his discovery, in 1839, of the "gas battery," and his subsequent indefatigable research in connection with the subject. As the result of his investigations the following list was compiled, in which each element of gas is electro-positive to all those which follow:—

(+) Metals which decompose water
Hydrogen
Carbonic Oxide
Phosphorus
Sulphur
Alcohol
Ether
Olefiant gas
Ethereal oils
Camphor
Metals which do not decompose water
Nitrogen
Carbonic acid
Nitric acid
Oxygen
Peroxides
Iodine
Bromine
Chlorine

The principle of the gas battery consists in substituting gases for the solid electrodes in a voltaic cell, the said gases, by their reaction one upon another and the electrolyte, having the effect of generating a current, available at the terminals of the cell, which latter usually take the form of metallic or carbon plates, immersed partly in the gas and partly in the electrolyte.

One of the most recent attempts to apply the principle of the gas battery to the solution of the problem indicated in the title of this article was that of Dr. W. Borcher's. His cell at first consisted of an outer glass or stoneware containing vessel, divided into two compartments communicating with each other at the bottom. In this vessel was placed an ammoniacal or acid solution of cuprous chloride: air was supplied to one compartment and carbonic oxide to the other. The electrodes were both of carbon, and yielded only a very weak current when connected.

An improvement on this form was shortly afterwards effected by substituting a copper electrode for the carbon in the carbonic oxide compartment. Coal gas also took the place of carbonic oxide, whilst acid solutions were found to give better results than those of an alkaline nature. By using the last-described form of apparatus, the external compartments being filled with copper turnings, a maximum electromotive force of 0.56 volt was obtained and, on short circuit, the cell was found to give 0.64 ampere. In a later form of this battery the outer containing vessel was constructed of copper and formed one of the electrodes. The inner cell was of perforated earthenware.

It was estimated that with Dr. Borcher's gas battery at least 27 per cent. of the fuel consumed is converted into electrical energy. Unfortunately, however, recent investigations tend to show that the evolution of a current from this type of cell is due rather to the solution of the valuable copper electrode than the desired carbon or coke, thereby discounting its apparent value in this connection.

The great difficulty met with in the practical application of the gas battery principle consists in the fact that the

current-producing capacity of the cell depends on the rate of occlusion of the gases by the electrodes employed. This occlusion, for all practical purposes, requires electrodes of an impracticable area, though it is possible that the preliminary storage of the gases under pressure might effect a saving in this direction. Researches in this field should, therefore, tend to the discovery of an electrode material which is capable of absorbing large volumes of gas and, at the same time, giving up such gas when required for reaction in the gas battery. The discovery of such a material would greatly extend the scope of the gas battery problem.

Summing up the various data so far available, it is fairly obvious that the final solution of the interesting problem of producing electrical energy directly from coal does not lie with the first three methods, which, as already noted, involve the preliminary generation of heat energy on a wasteful plan. The matter, therefore, lies, so far, with the voltaic cell in which carbon is the consumed electrode and the gas battery, and it is just possible, though hardly probable in the immediate future, and under present known scientific conditions, that either of these methods, or a successful combination of the two, may provide us with a scientific solution. On the other hand, it must be remembered that the apparatus will probably prove cumbersome and costly, so that although the theoretical efficiency might be as high as 70 or even 80 per cent., the great interest on capital outlay would probably be a prohibition to its commercial adoption.

An International Exhibition at Liege, Belgium

An international exhibition will be held at Liege, Belgium, beginning April 22, 1905. The site selected is a specially favorable one, a large area in the valley of the Meuse, including the beautiful Parc de Cointe, having been reserved. The general features of the exhibition will be those which usually characterize international undertakings of this character, and there will also be special attractions for visitors, and a Colonial section of interest and importance.

The contents of the various buildings will be classified in 21 groups, comprising all branches of industry, art and science. A large portion of the exhibition is to be devoted to mechanical appliances, and it is intended to show machines in actual work. A feature of the exhibition to which much attention will be paid, and from which important results are expected, is a series of congresses and conferences, which will be held at intervals in the six months during which the exhibition will remain open.

Water Required for Gas Engines

According to "The Engineer," the quantity of water required at the ordinary temperature of 60 degrees F. inlet, and 150 degrees outlet, to keep the cylinders of gas engines cool is 4.5 to 5 gallons per indicated horse-power-hour. The jacket pipe should be from 1 to 2 inches diameter for engines up to 20 H. P., while for larger engines the sizes are generally 2 to 3 inches for the inlet and 2.5 to 3.5 inches for the outlet. Tanks for circulating the water are generally made with a capacity for furnishing 20 to 30 gallons per indicated horse-power.

Standardizing Electric Motors for Machine Tools

In a communication to the recent convention of the National Machine Tool Builders' Association, Fred A. Geier says that though much of the uncertainty connected with the design of tools suitable for motor driving has been eliminated in the past twelve months, a satisfactory solution of the general problem has not yet been arrived at. It will be necessary for machine tool builders to first decide upon a standard speed range for variable-speed motors, covering the entire field of machine tool driving.

From experience it is found that a speed variation of 150 per cent. in the motor is needed—that is, a maximum speed of 2½ times the minimum speed. This is more speed range than is required by some tools, but probably falls a little short of the range required by others. However, it would seem that a motor that would be suited to milling machine driving would have plenty of range for any machine tool.

One large manufacturer of milling machines has adopted the 2½ to 1 variation in speed, and is prepared to furnish machines with any one of half a dozen different motors, thus allowing a wide selection in the latter regard for their customers. But each one of the half-dozen motors is different in shape and size from the others, and thus necessitates the making of special parts for each order. This prevents standardizing all parts and carrying them in stock, and therefore increases the cost of the motor-driven machine considerably over what it would be if all makes of motors of given horse-powers had frames that were standard in certain important particulars. In order to manufacture motor-drive parts for machine tools economically, by making them up in lots for stock, motor frames must be standardized in the following respects:—

First—Size and shape of the base.

Second—Distance from the center of the driving pulley to the center of the base.

Third—Height of the motor from the bottom of the base to the center of the armature shaft.

Fourth—Diameter of the armature shaft.

For a standard speed variation he believed that 2½, or at most 3, to 1 would be entirely satisfactory to meet the general problem, and these speeds should, of course, be kept as low as possible, with a minimum speed somewhere below 700 revolutions per minute.

The Ohio Society of Mechanical, Electrical and Steam Engineers

On Friday and Saturday, November 18 and 19, the Ohio Society of Mechanical, Electrical and Steam Engineers held its fall meeting at Canton, Ohio. President R. H. Probert, of Akron, Ohio, presided and the following papers were read:—"Some Facts and Features about Electric Meters," by H. C. Fashbaugh; "Notes on Solenoid Electric Mechanical Governors, as Applied to Turbines and Impact Wheels," by Frank S. Replogle; "System for Daily Inventory of Plant Cost," by James L. Butler; "Liquid Fuel and Oil Burners," by George G. Bennett; "Heavy-Duty Engine Service in a Modern Steel Plant," by Arthur L. Strickland; "Boilers and Furnaces," by W. C. McCracken; "Notes on Boiler Tests," by J. E. Bell; "Gas Engines in Power Plants," by Wm. T. Magruder; "Electrically Driven Chapman Valves," by Herbert E. Stone; "The Modern Steam Fire Engine," by F. F. Loomis.

On Friday a visit was made to the Dueber-Hampden Watch Works, the largest watch works in the world, and on Saturday the plant of the Russell Engine Company, at Massillon, Ohio, was inspected. The annual election of officers ended the Saturday session.

The Puget Sound Power Company, employing the power of the Puyallup River in Washington for the generation and transmission of a 55,000-volt current to Seattle and Tacoma, makes use of a flume 10 miles long for carrying the water from its point of diversion in the river to the power house, where a head of 872 feet is obtained.